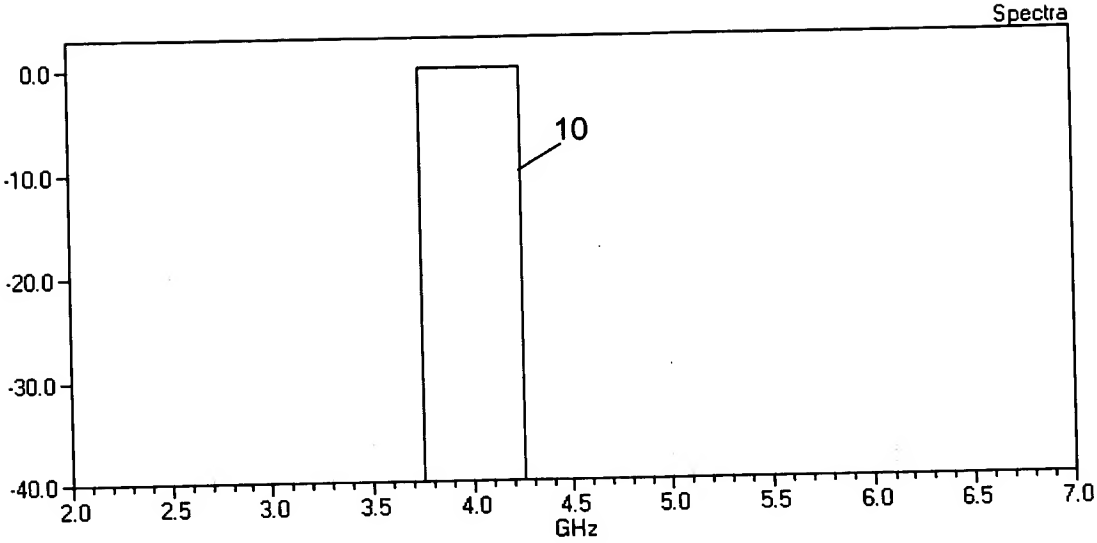

Spectra
0.0
-10.0
-20.0
-30.0
-40.0
10
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
GHz

FIG. 1

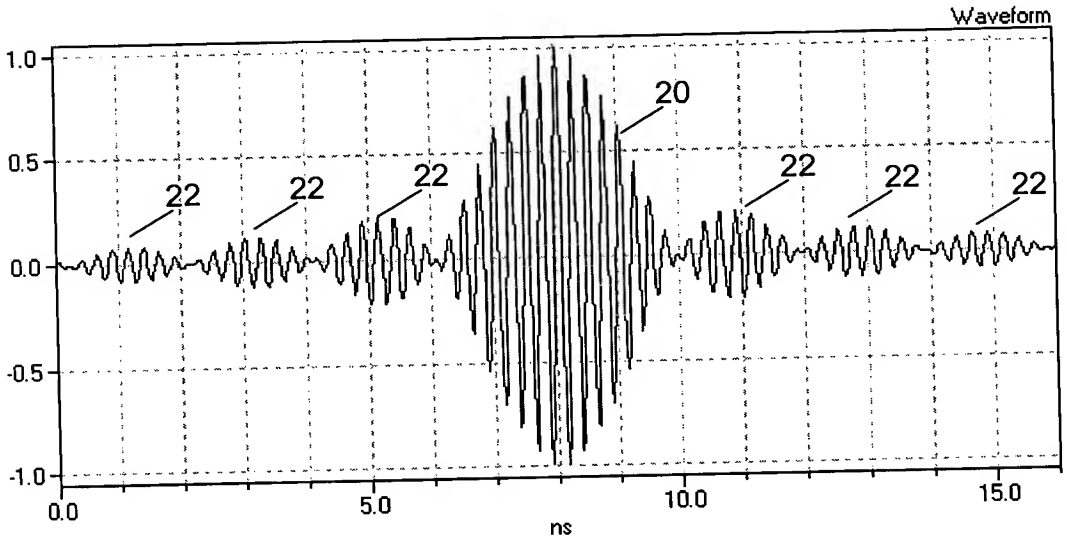

Waveform
1.0
0.5
0.0
-0.5
-1.0
20
22
22
22
22
22
22
0.0
5.0
10.0
15.0
ns

FIG. 2

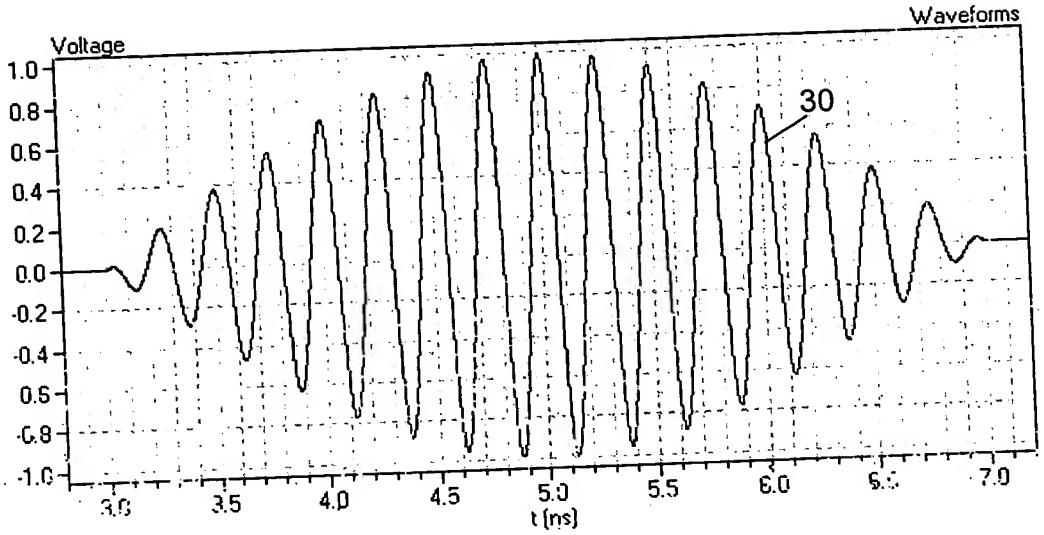

Waveforms
Voltage
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
30
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
t (ns)

FIG. 3

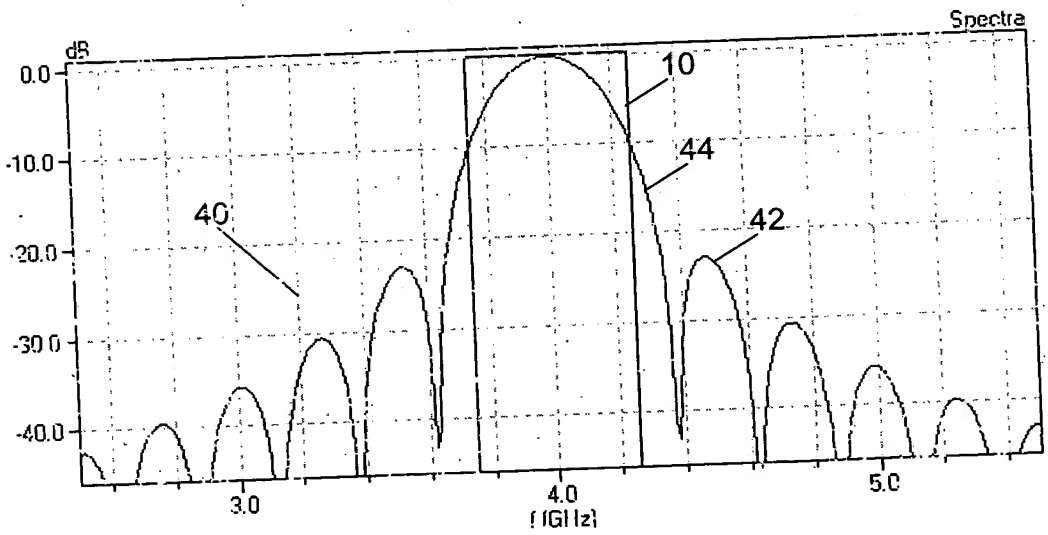

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
44
42
40
3.0
4.0
5.0
f (GHz)

FIG. 4

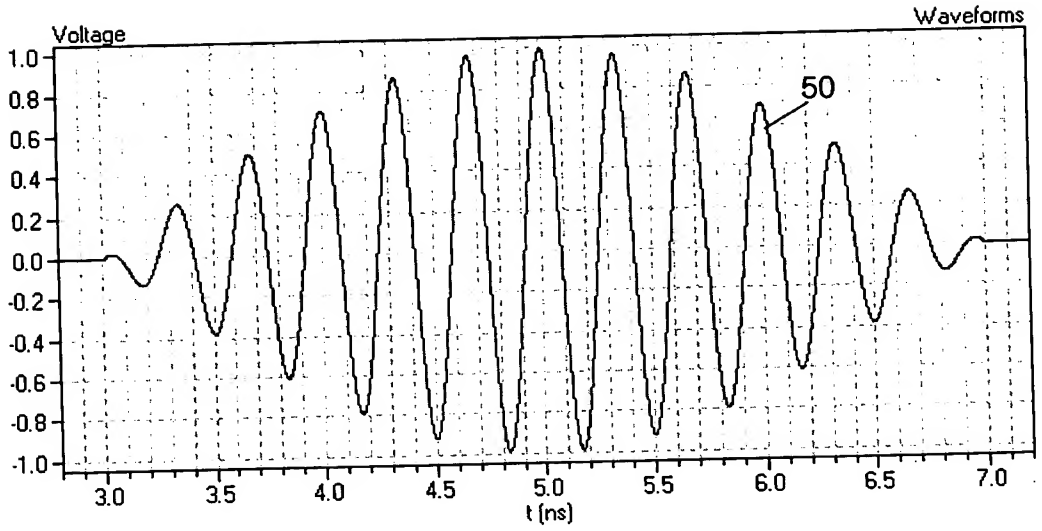

Waveforms
Voltage
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
50
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
t (ns)

FIG. 5

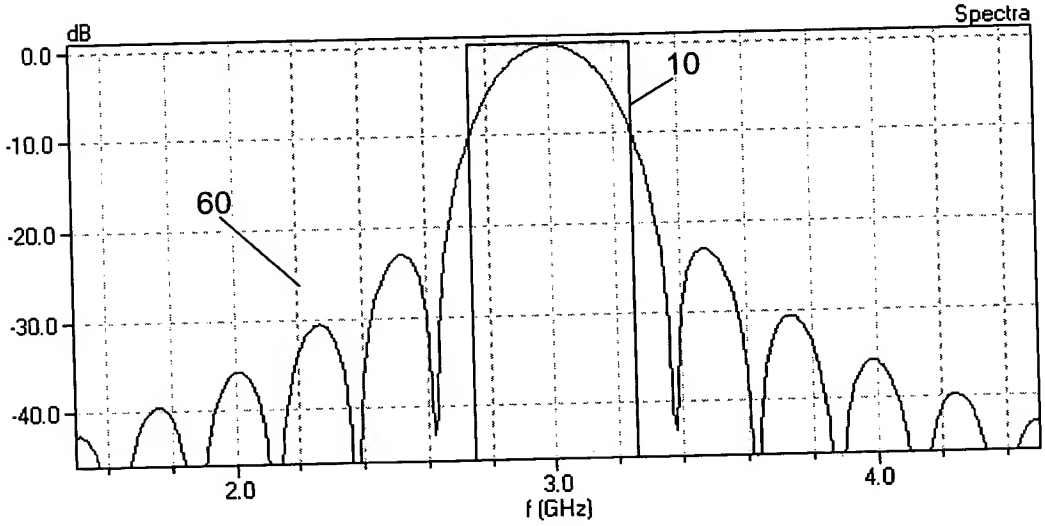

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
60
2.0
3.0
4.0
f (GHz)

FIG. 6

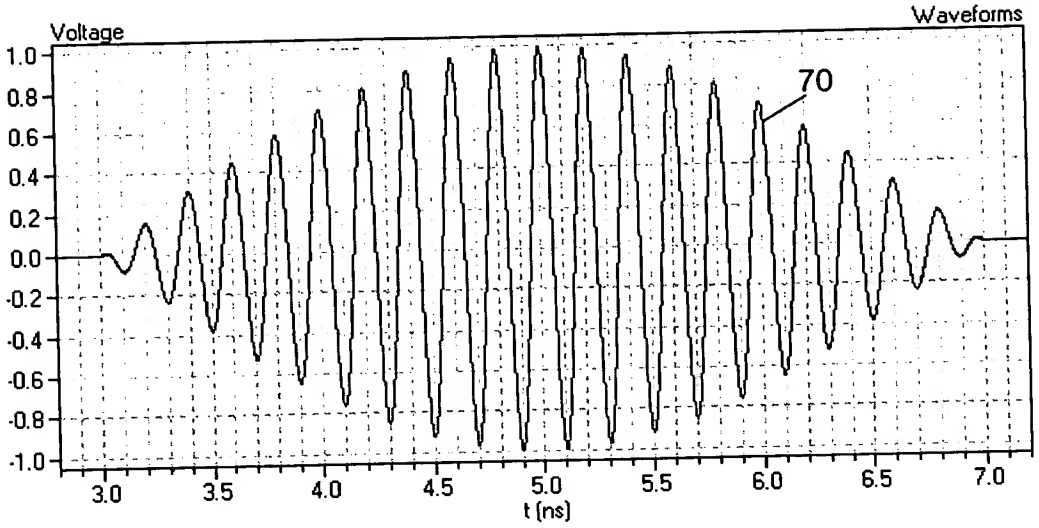

Waveforms
Voltage
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
70
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
t (ns)

FIG. 7

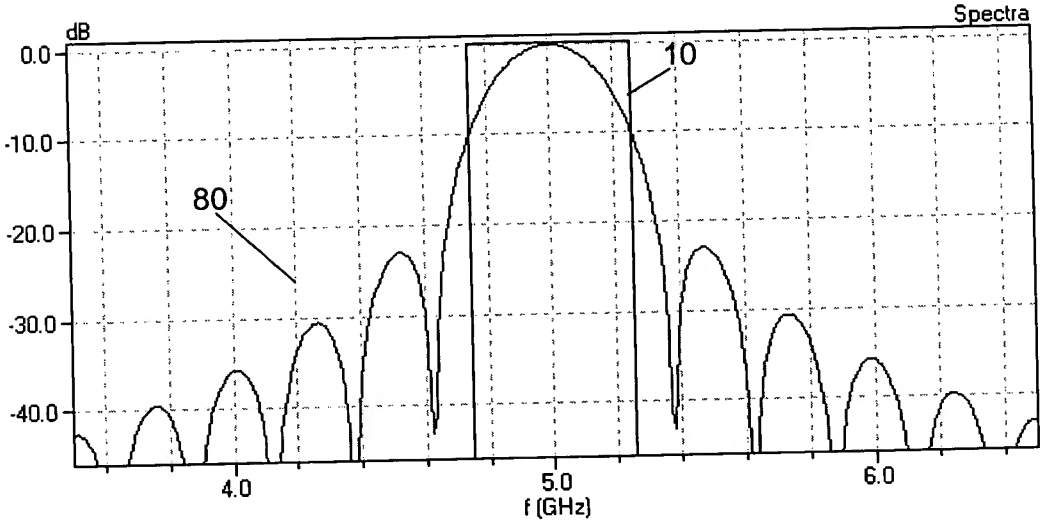

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
80
4.0
5.0
6.0
f (GHz)

FIG. 8

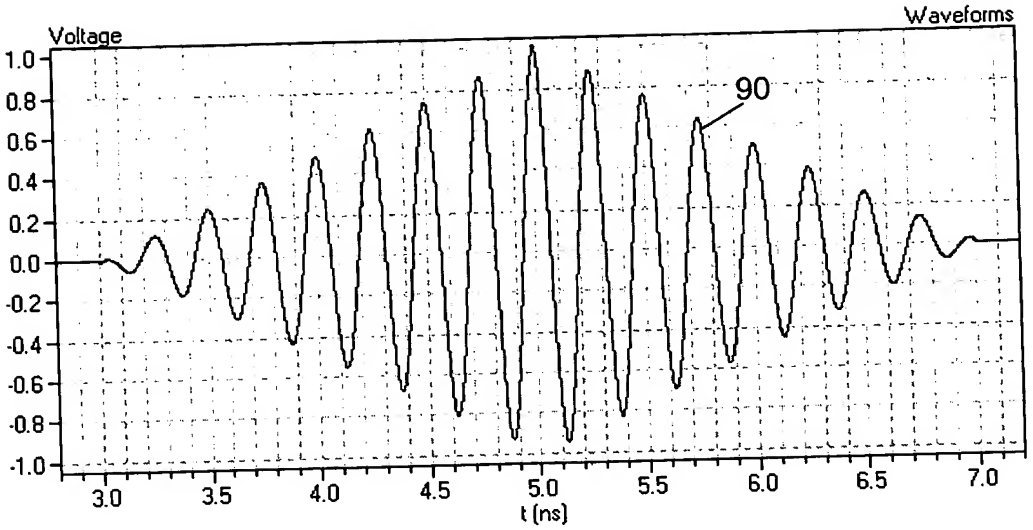

Waveforms
Voltage
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
90
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
t (ns)

FIG. 9

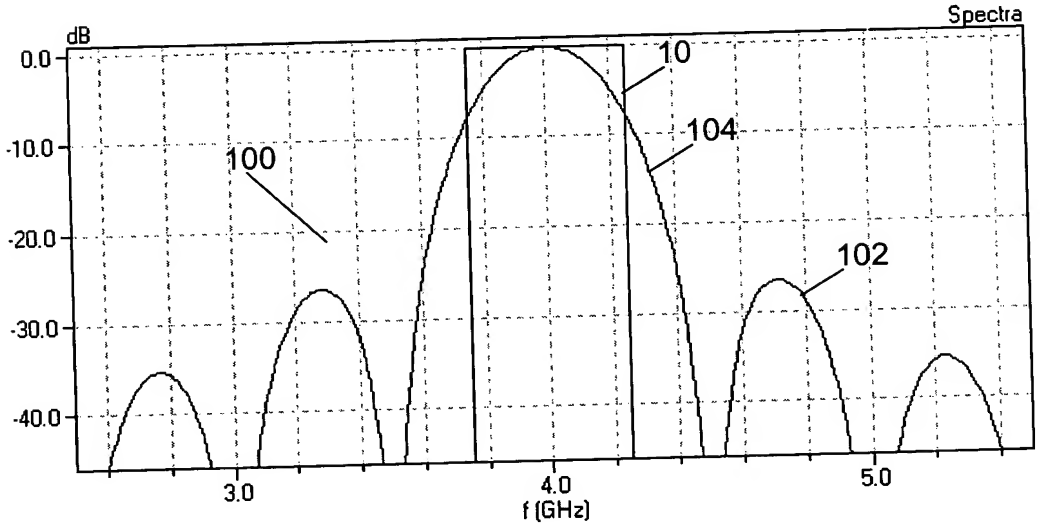

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
104
100
102
3.0
4.0
5.0
f (GHz)

FIG. 10

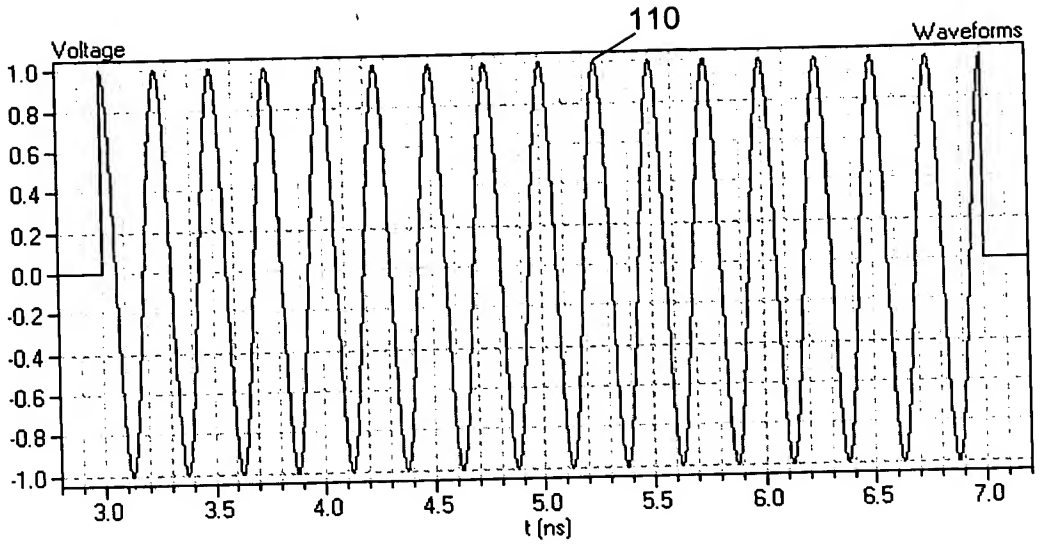

110
Waveforms
Voltage
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
t (ns)

FIG. 11

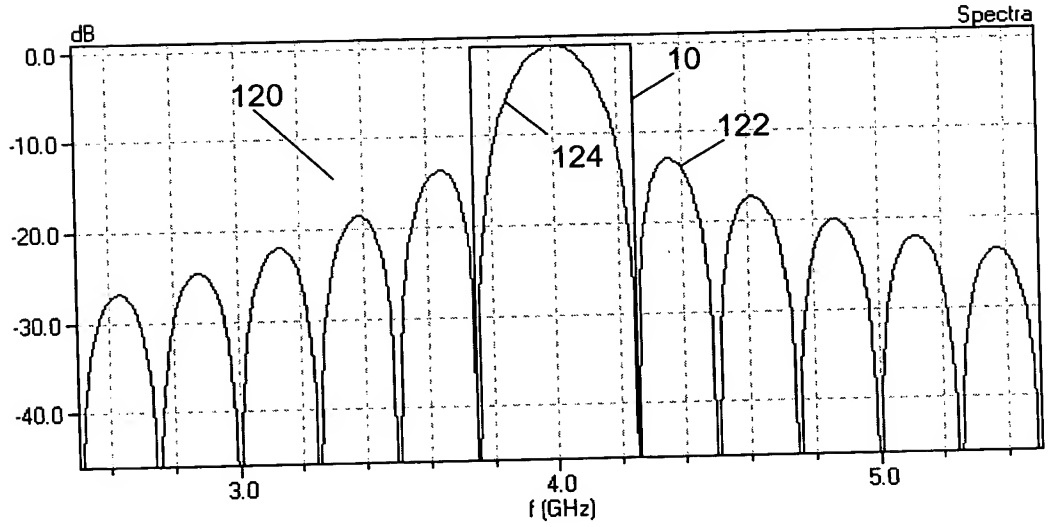

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
120
10
122
124
3.0
4.0
5.0
f (GHz)

FIG. 12

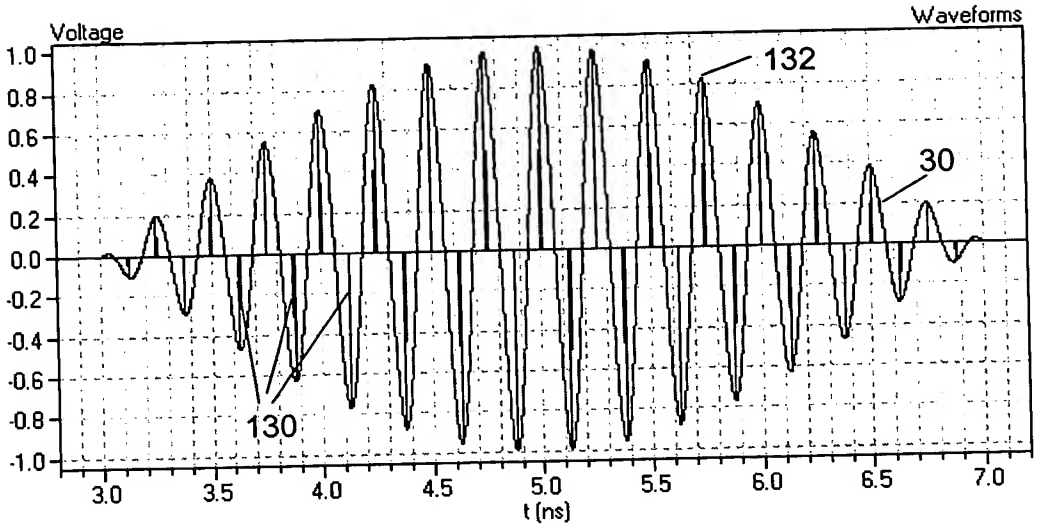

Waveforms
Voltage
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
132
30
130
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
t (ns)

FIG. 13

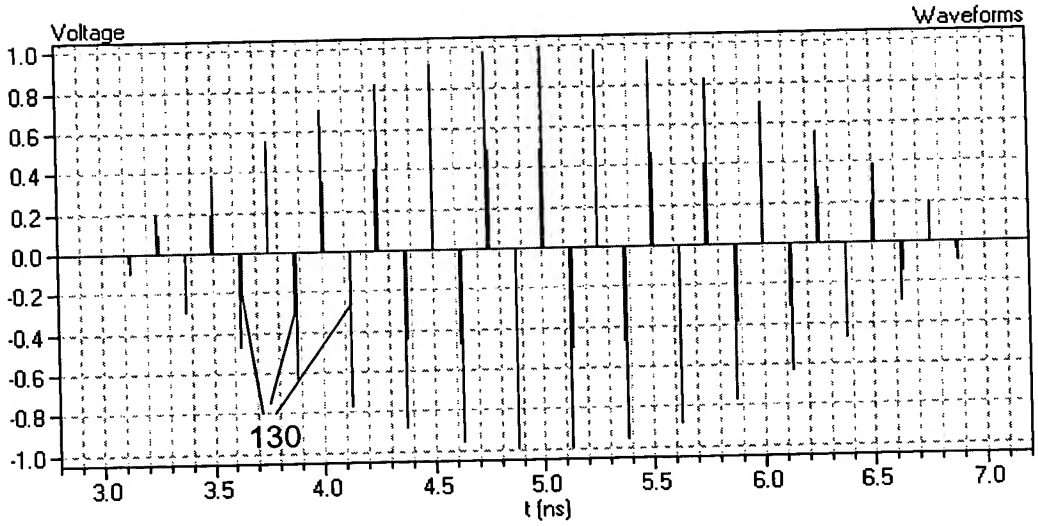

Waveforms
Voltage
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
130
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
t (ns)

FIG. 14

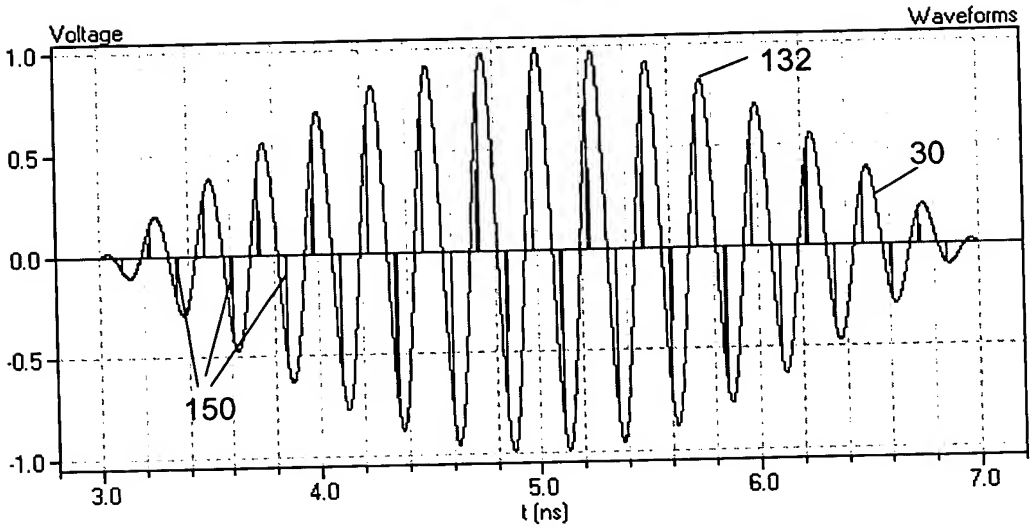

Waveforms
Voltage
1.0
0.5
0.0
-0.5
-1.0
132
30
150
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 15

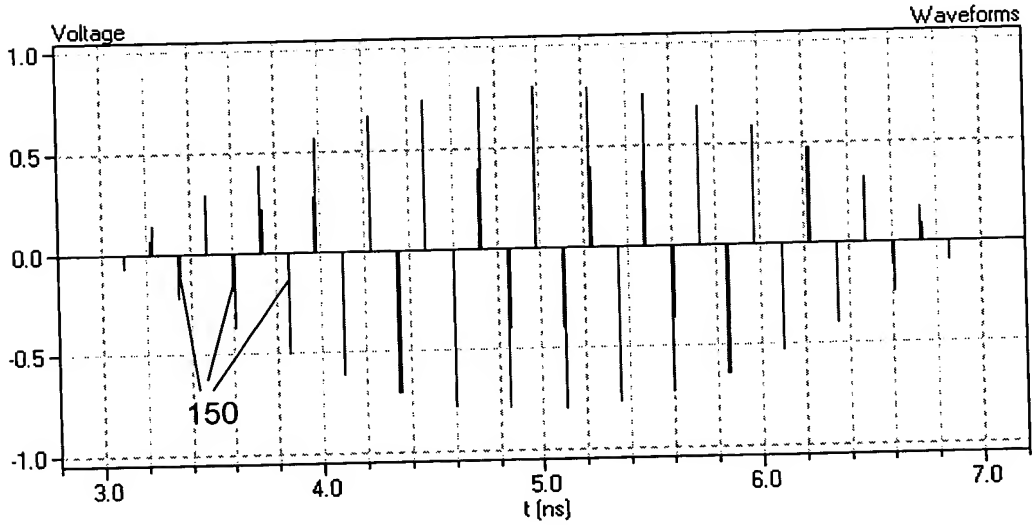

Waveforms
Voltage
1.0
0.5
0.0
-0.5
-1.0
150
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 16

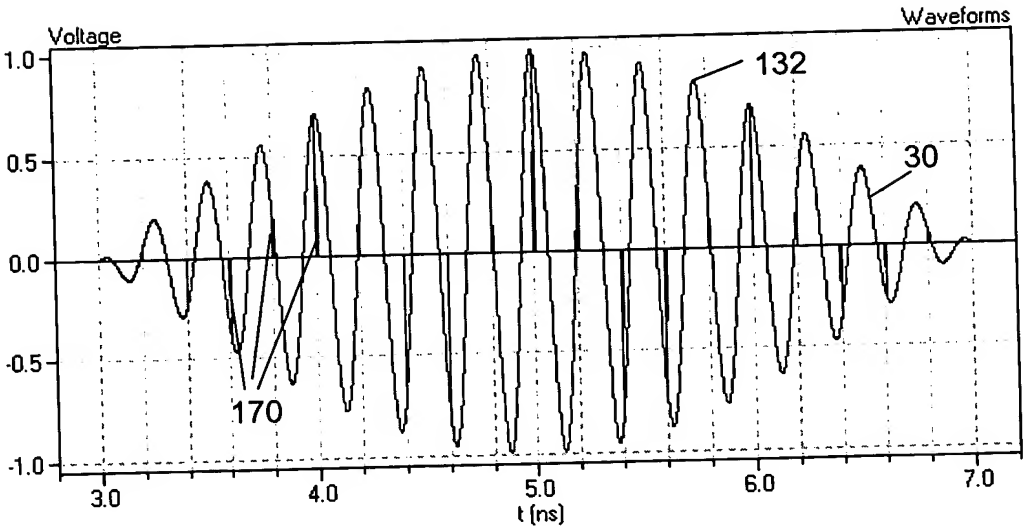

Waveforms
Voltage
1.0
0.5
0.0
-0.5
-1.0
132
30
170
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 17

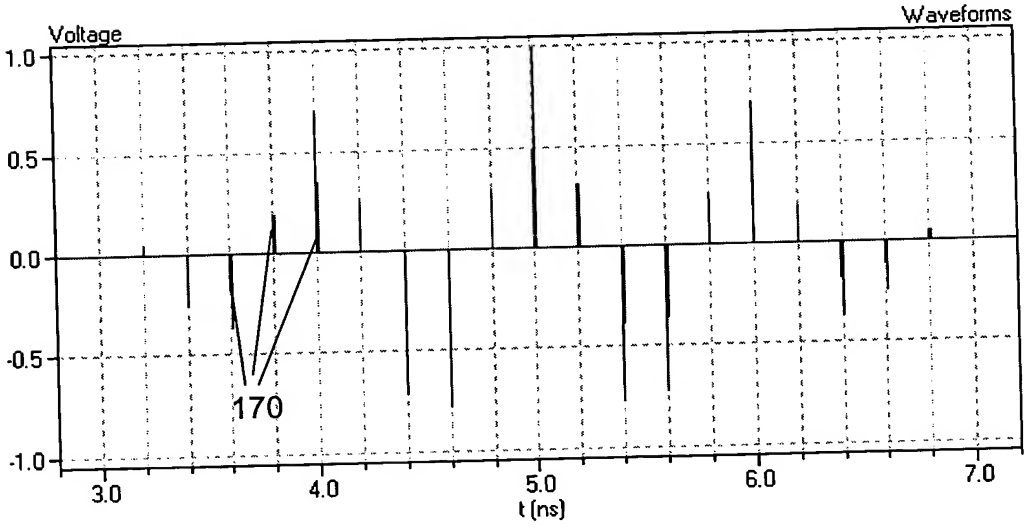

Waveforms
Voltage
1.0
0.5
0.0
-0.5
-1.0
170
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 18

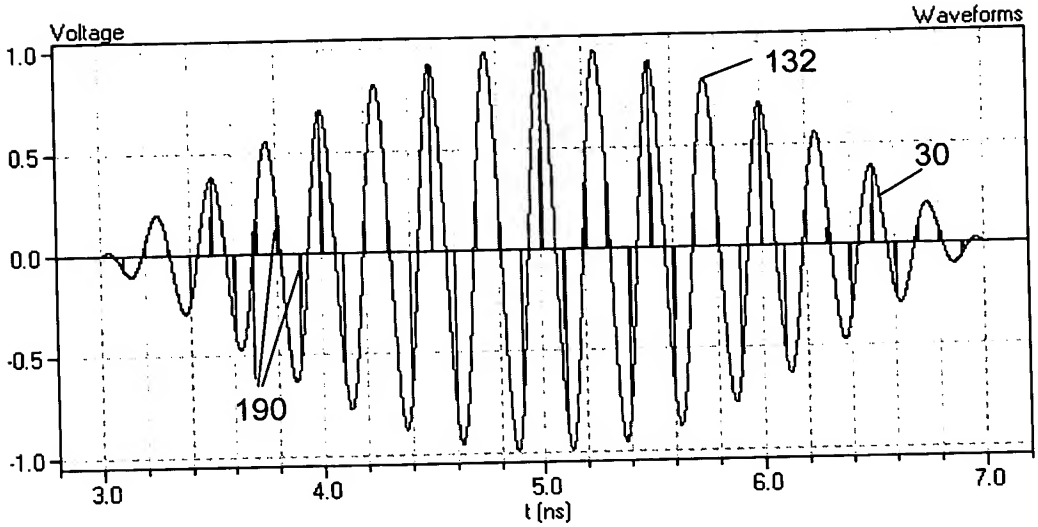

Waveforms
Voltage
1.0
0.5
0.0
-0.5
-1.0
132
30
190
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 19

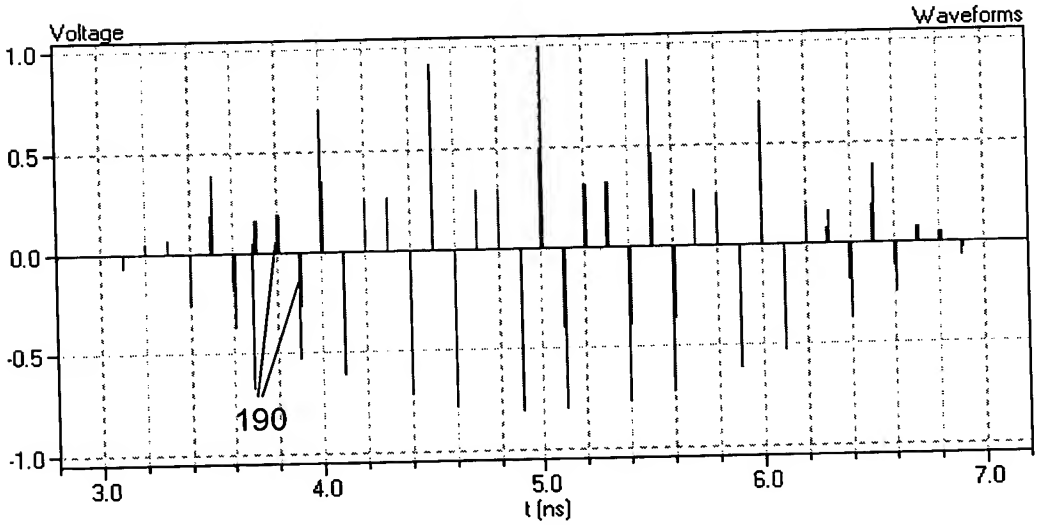

Waveforms
Voltage
1.0
0.5
0.0
-0.5
-1.0
190
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 20

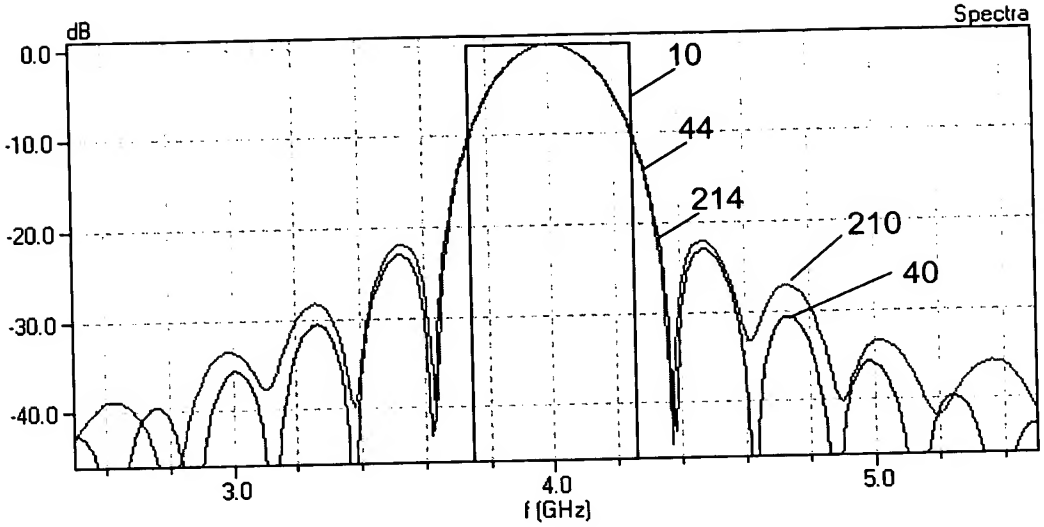

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
44
214
210
40
3.0
4.0
5.0
f (GHz)

FIG. 21

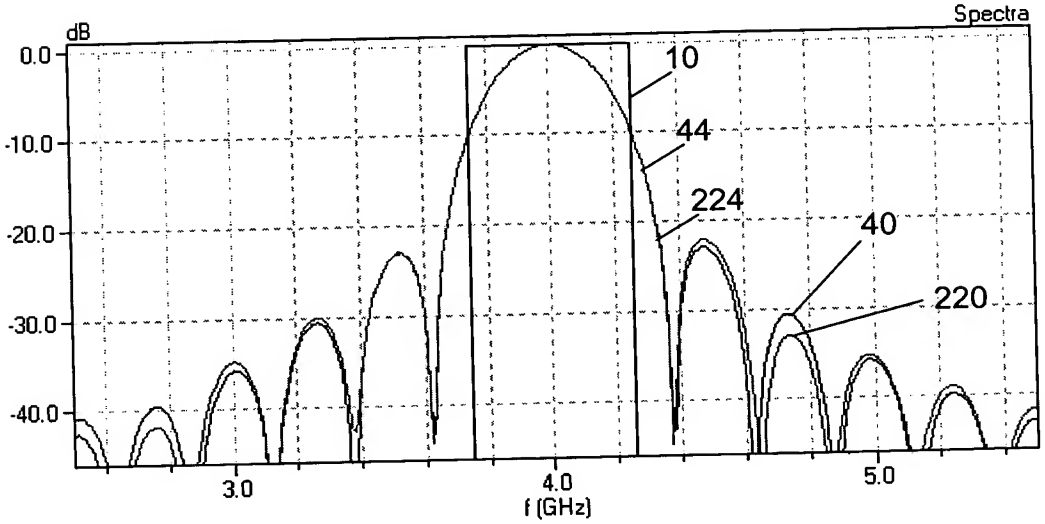

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
44
224
40
220
3.0
4.0
5.0
f (GHz)

FIG. 22

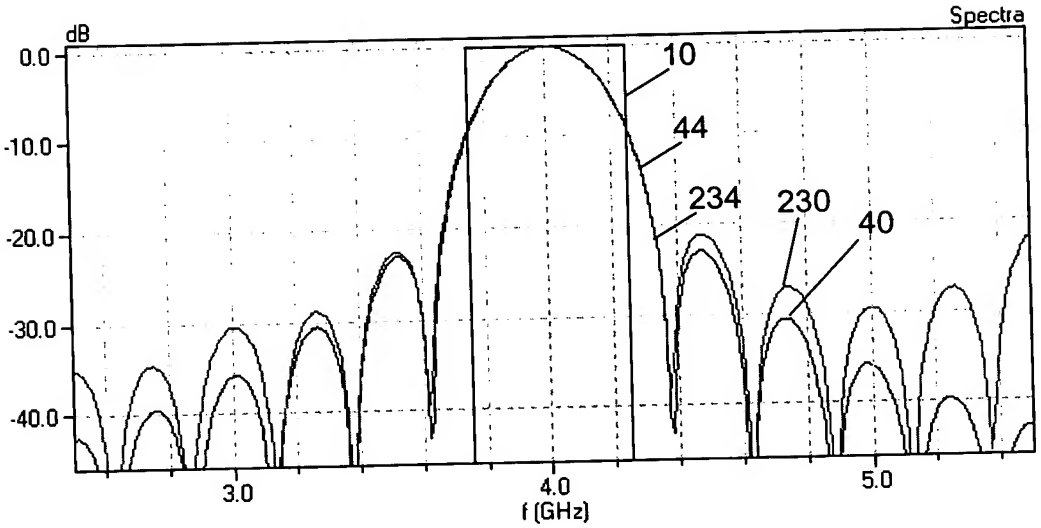

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
44
234
230
40
3.0
4.0
5.0
f (GHz)

FIG. 23

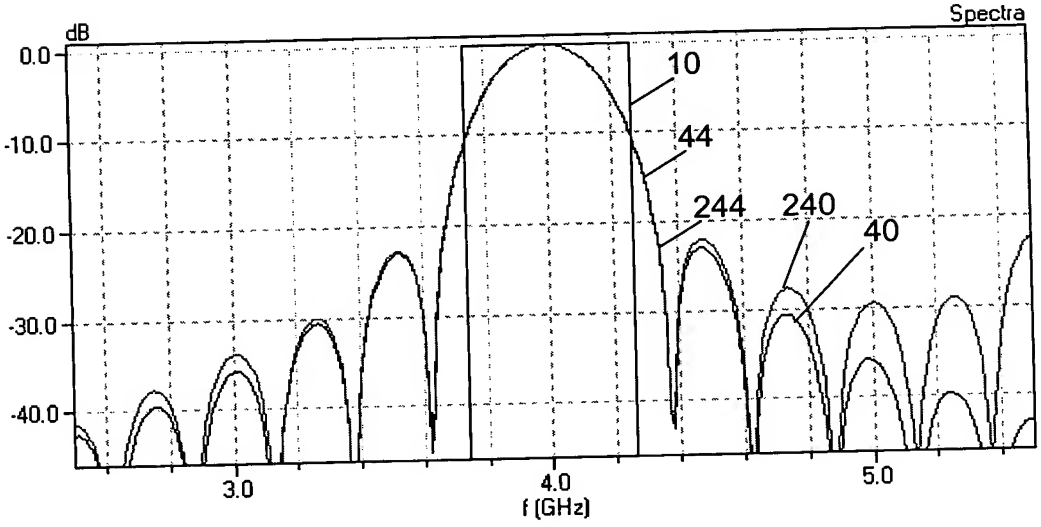

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
44
244
240
40
3.0
4.0
5.0
f (GHz)

FIG. 24

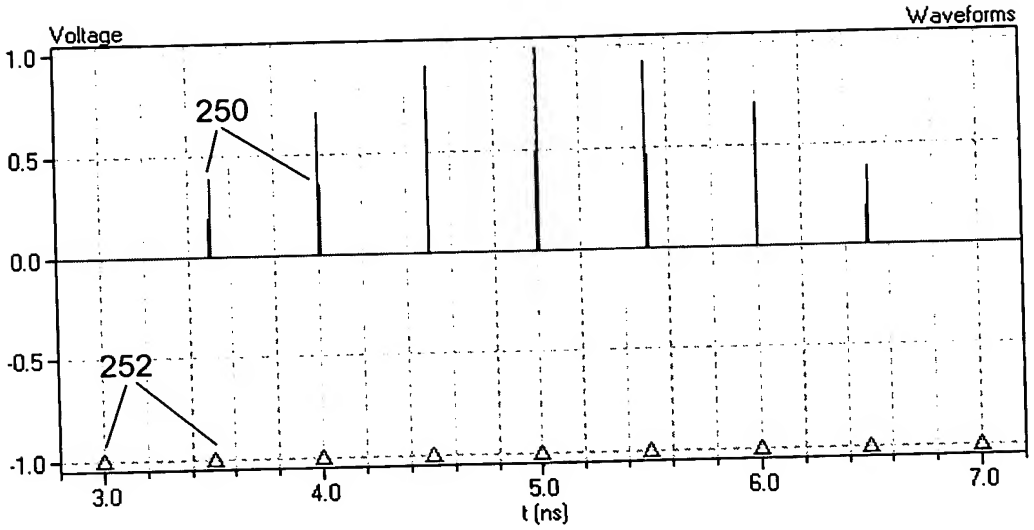

Waveforms
Voltage
1.0
0.5
0.0
-0.5
-1.0
250
252
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 25

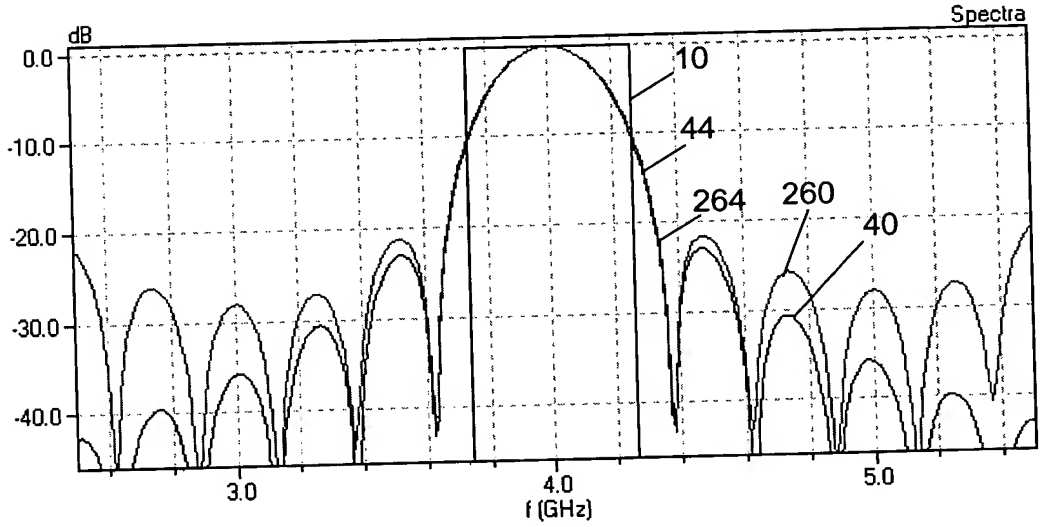

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
44
264
260
40
3.0
4.0
5.0
f (GHz)

FIG. 26

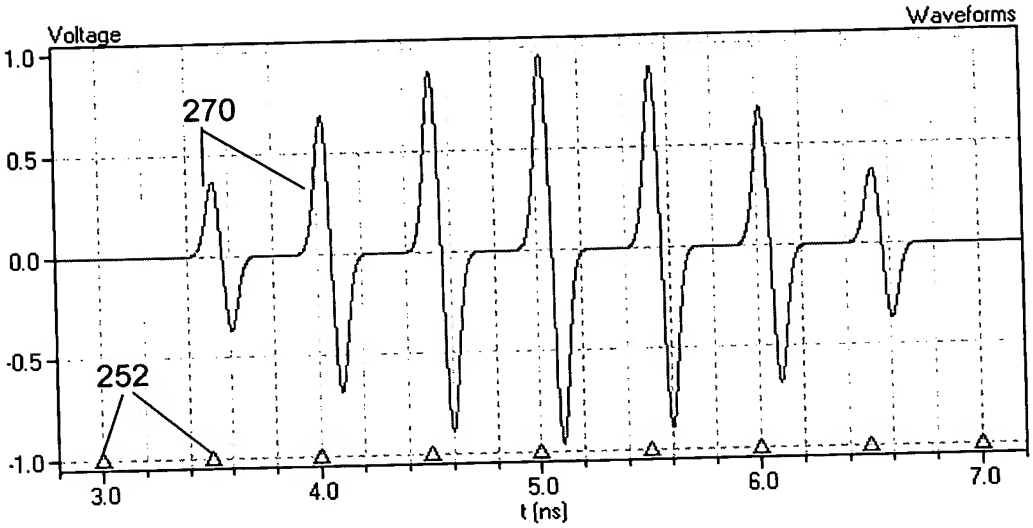

Waveforms
Voltage
1.0
0.5
0.0
-0.5
-1.0
270
252
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 27

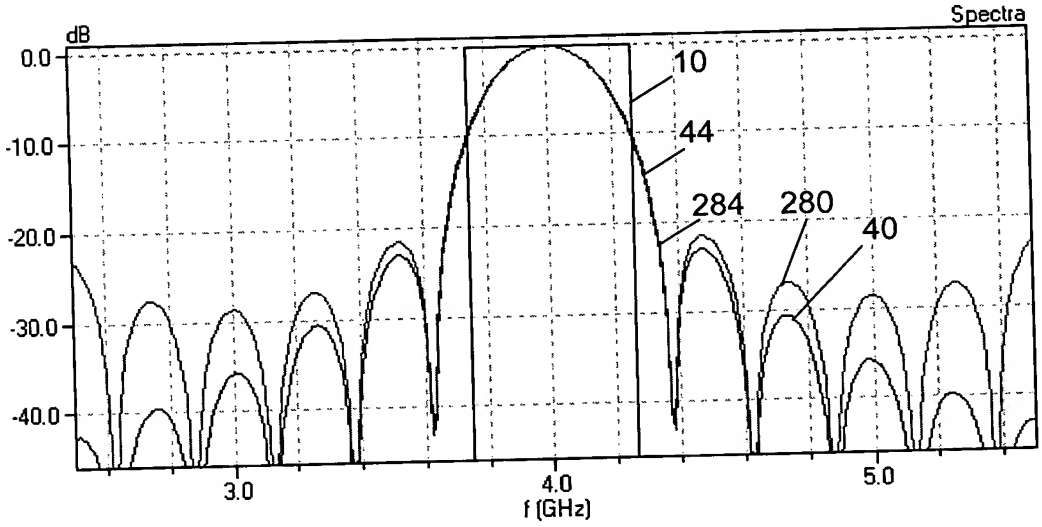

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
44
284
280
40
3.0
4.0
5.0
f (GHz)

FIG. 28

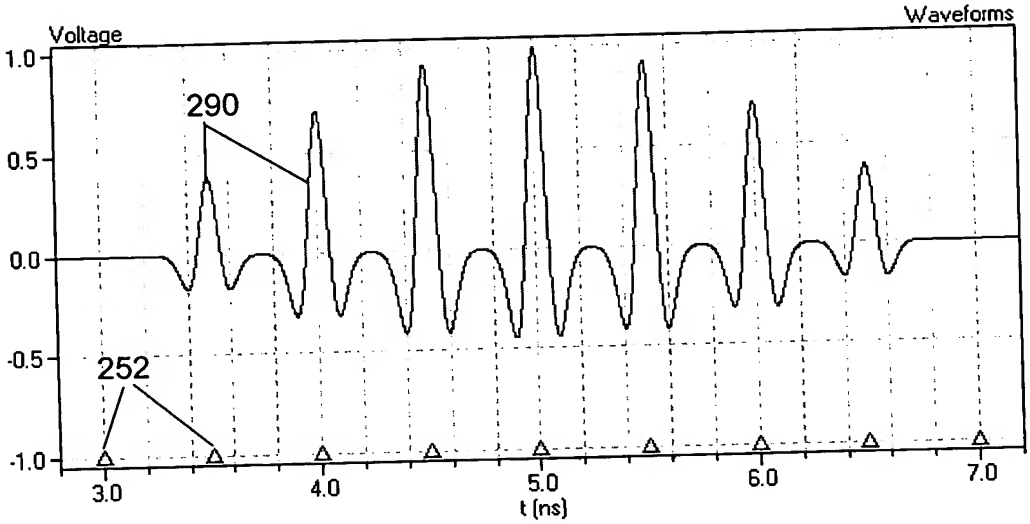

Waveforms
Voltage
1.0
0.5
0.0
-0.5
-1.0
290
252
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 29

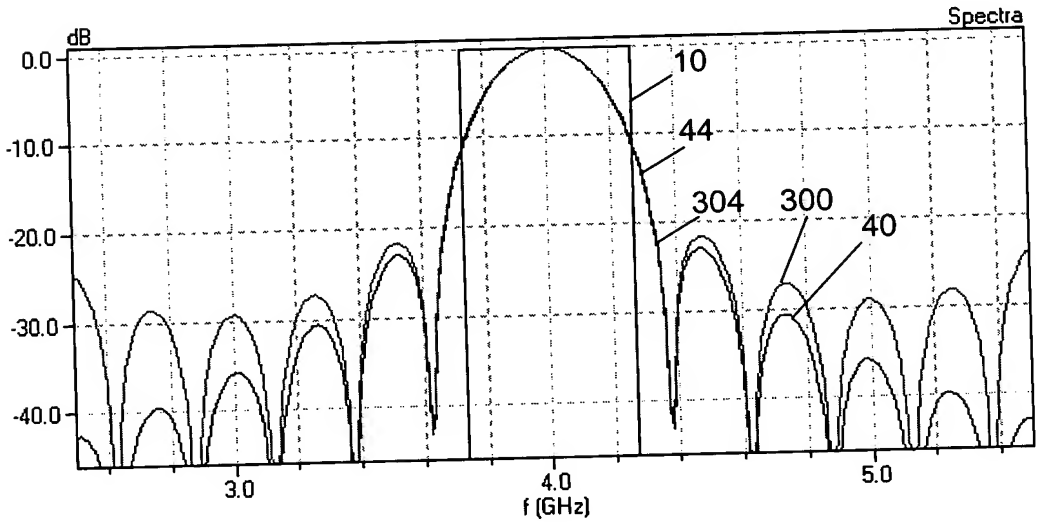

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
44
304
300
40
3.0
4.0
5.0
f (GHz)

FIG. 30

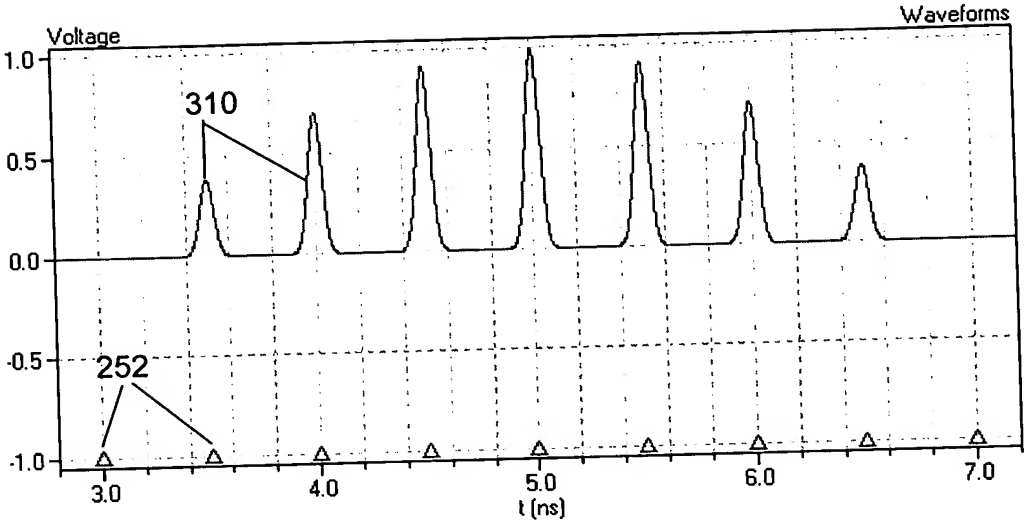

Waveforms
Voltage
1.0
0.5
0.0
-0.5
-1.0
310
252
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 31

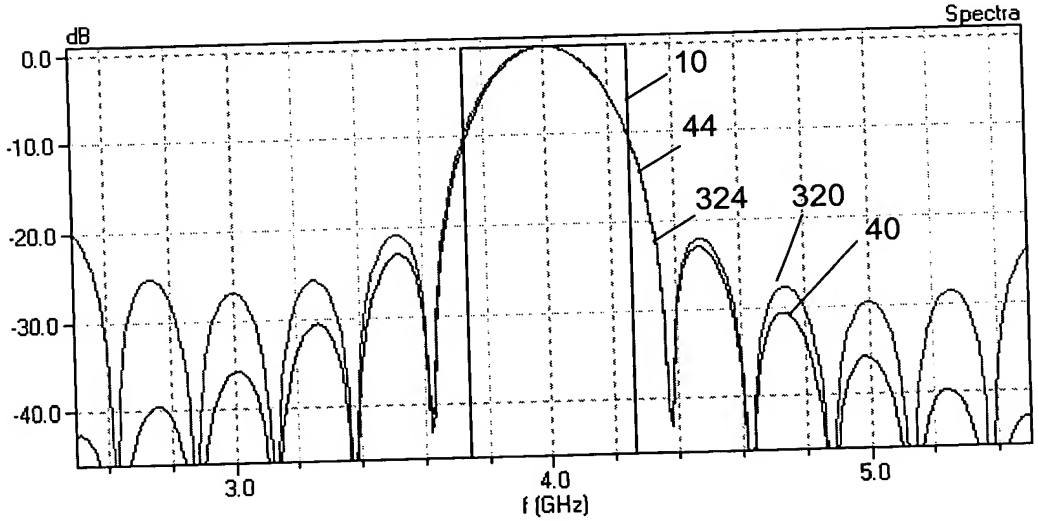

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
44
324
320
40
3.0
4.0
5.0
f (GHz)

FIG. 32

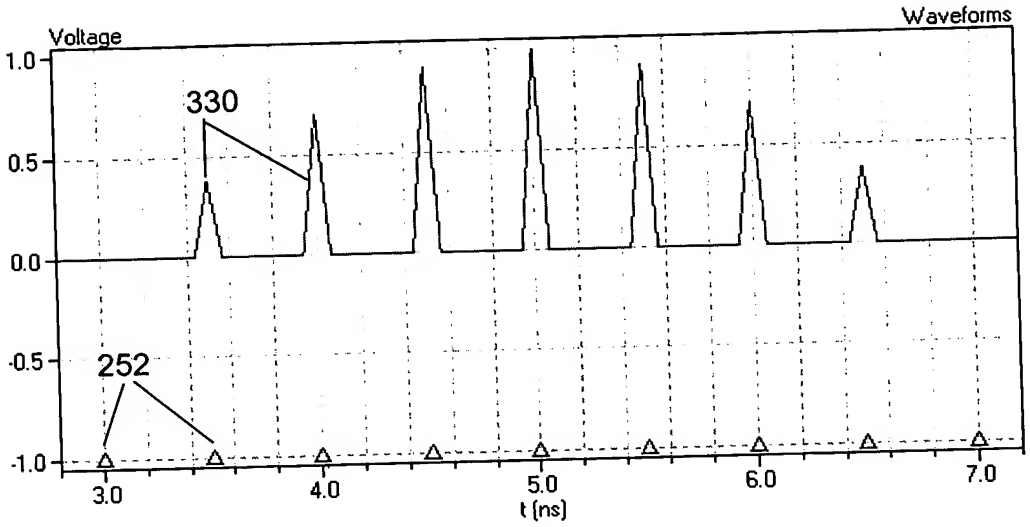

Waveforms
Voltage
1.0
0.5
0.0
-0.5
-1.0
330
252
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 33

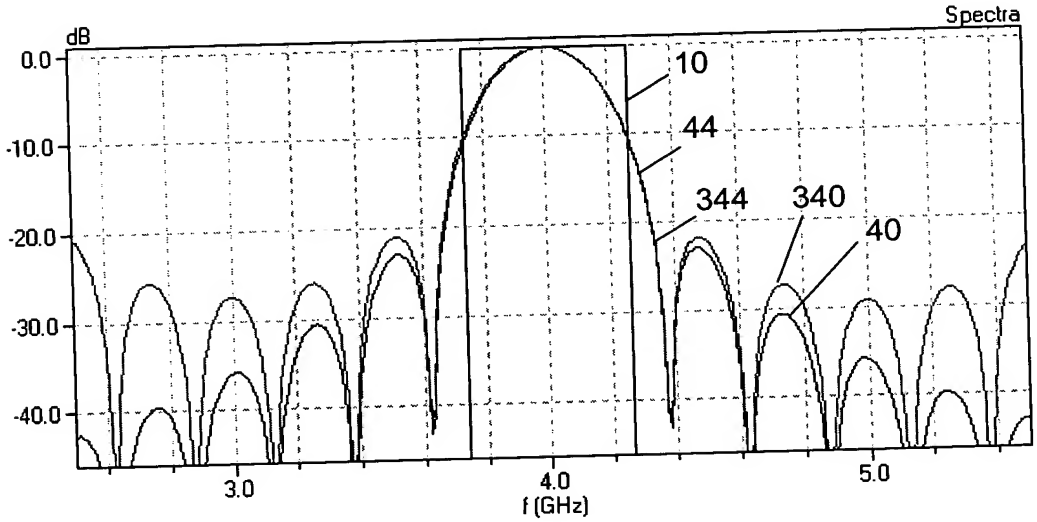

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
44
344
340
40
3.0
4.0
5.0
f (GHz)

FIG. 34

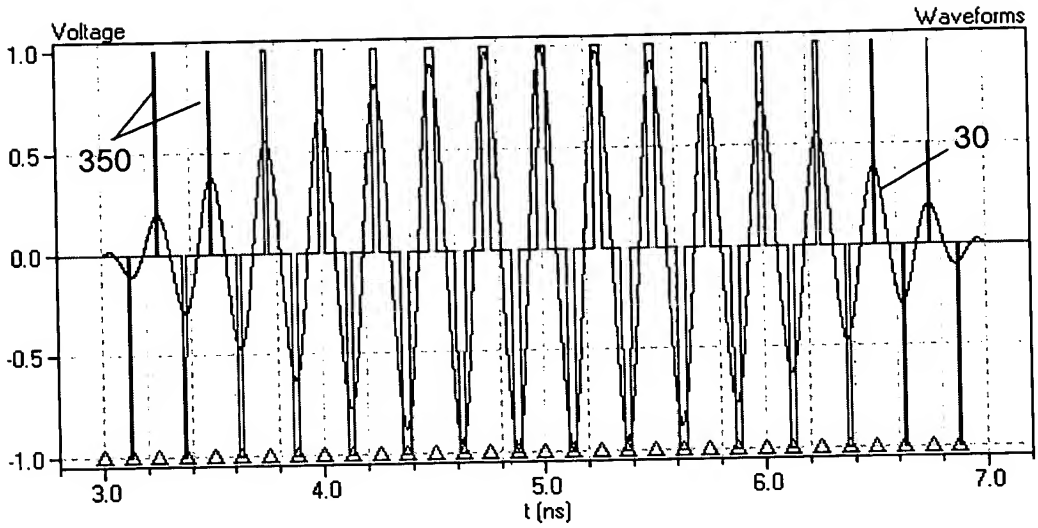

Waveforms
Voltage
1.0
0.5
0.0
-0.5
-1.0
350
30
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 35

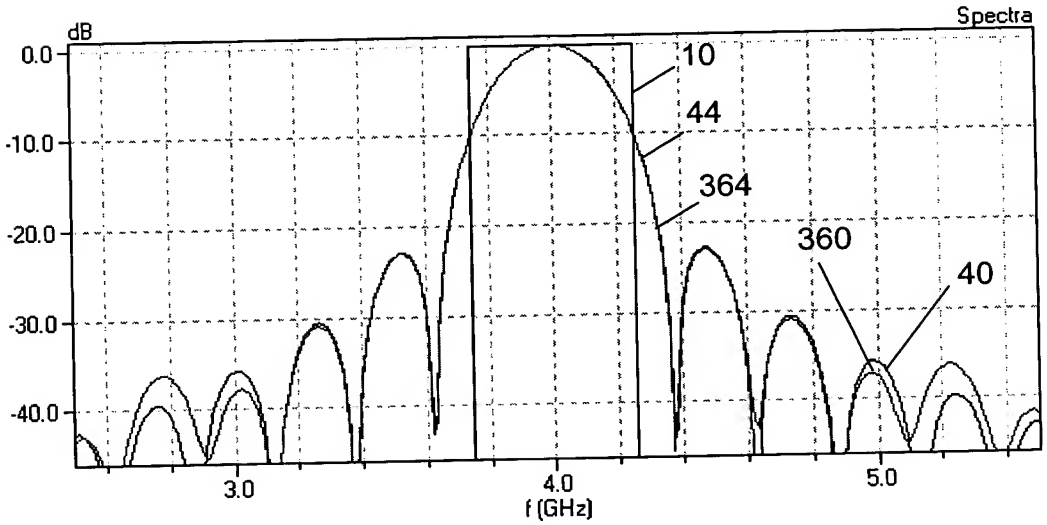

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
10
44
364
360
40
3.0
4.0
5.0
f (GHz)

FIG. 36

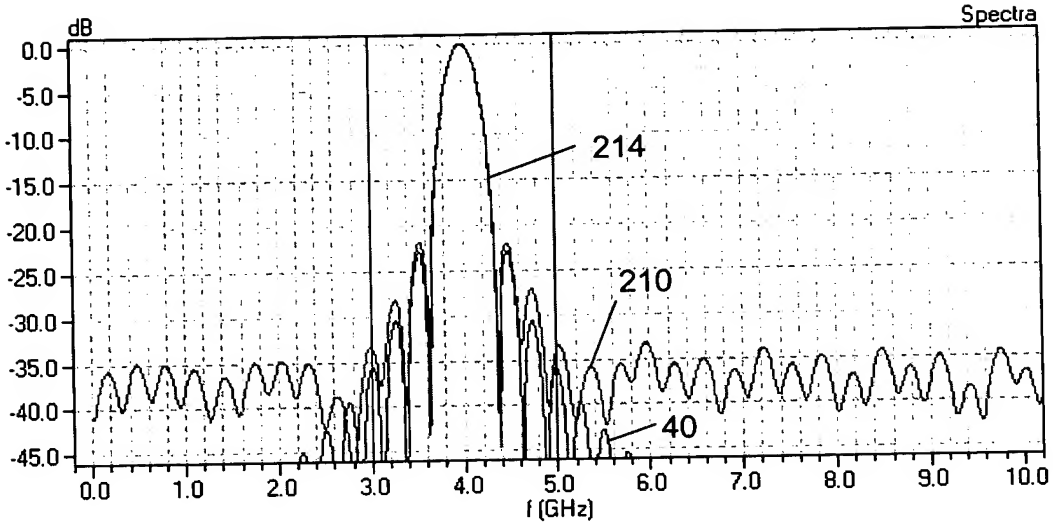

Spectra
dB
0.0
-5.0
-10.0
-15.0
-20.0
-25.0
-30.0
-35.0
-40.0
-45.0
214
210
40
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
f (GHz)

FIG. 37

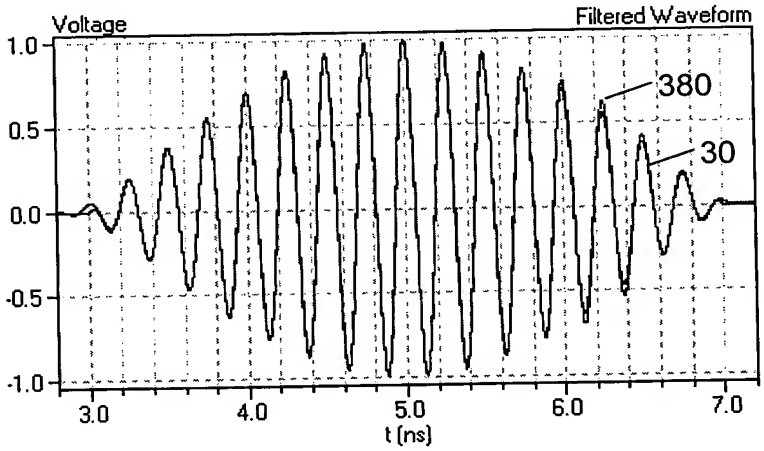

Voltage
Filtered Waveform
1.0
0.5
0.0
-0.5
-1.0
380
30
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 38

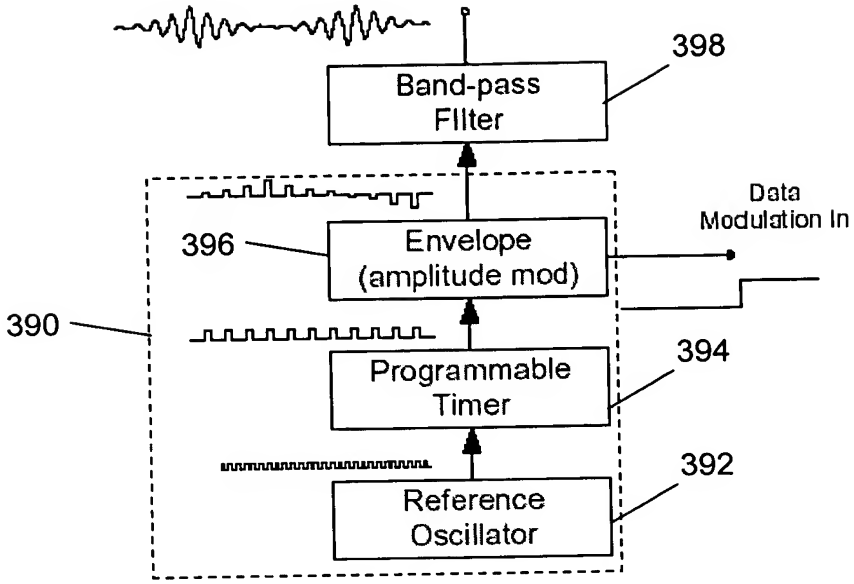

398
Band-pass
FIlter
Data
Modulation In
396
Envelope
(amplitude mod)
390
394
Programmable
Timer
392
Reference
Oscillator

FIG. 39

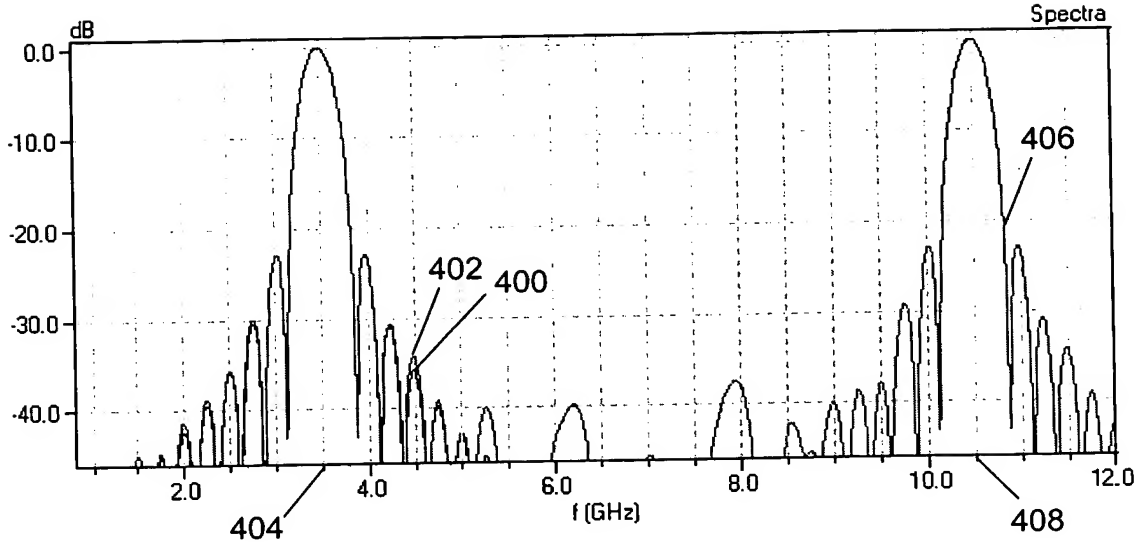

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
2.0
4.0
6.0
8.0
10.0
12.0
f (GHz)
406
402
400
404
408

FIG. 40

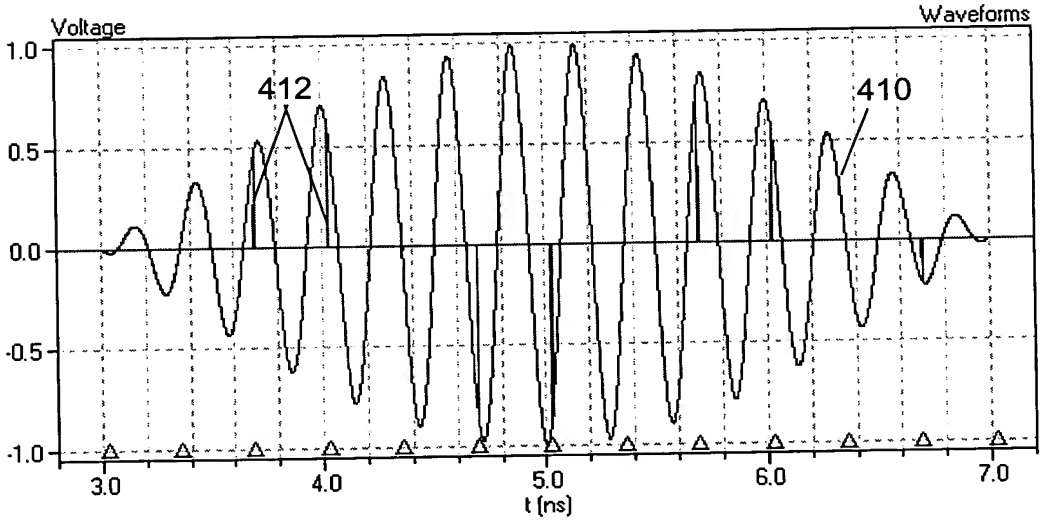

Voltage
Waveforms
1.0
0.5
0.0
-0.5
-1.0
3.0
4.0
5.0
6.0
7.0
t (ns)
412
410

FIG. 41

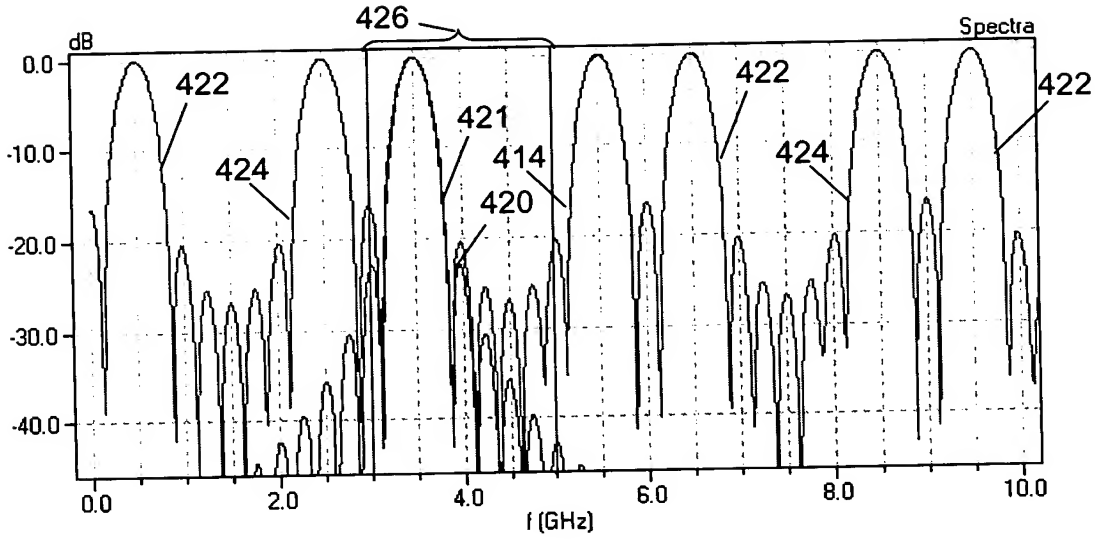

426
dB
Spectra
0.0
-10.0
-20.0
-30.0
-40.0
422
424
421
414
420
422
424
422
0.0
2.0
4.0
6.0
8.0
10.0
f (GHz)

FIG. 42

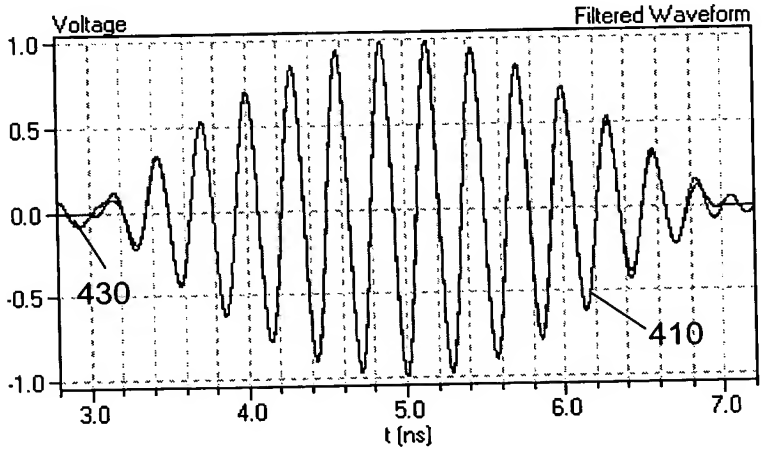

Voltage
Filtered Waveform
1.0
0.5
0.0
-0.5
-1.0
430
410
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 43

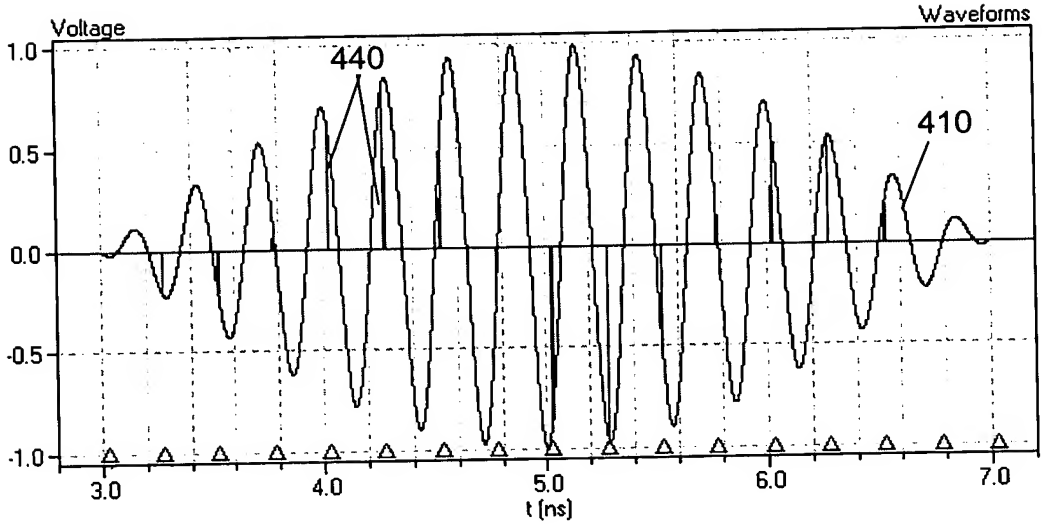

Voltage
Waveforms
1.0
0.5
0.0
-0.5
-1.0
440
410
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 44

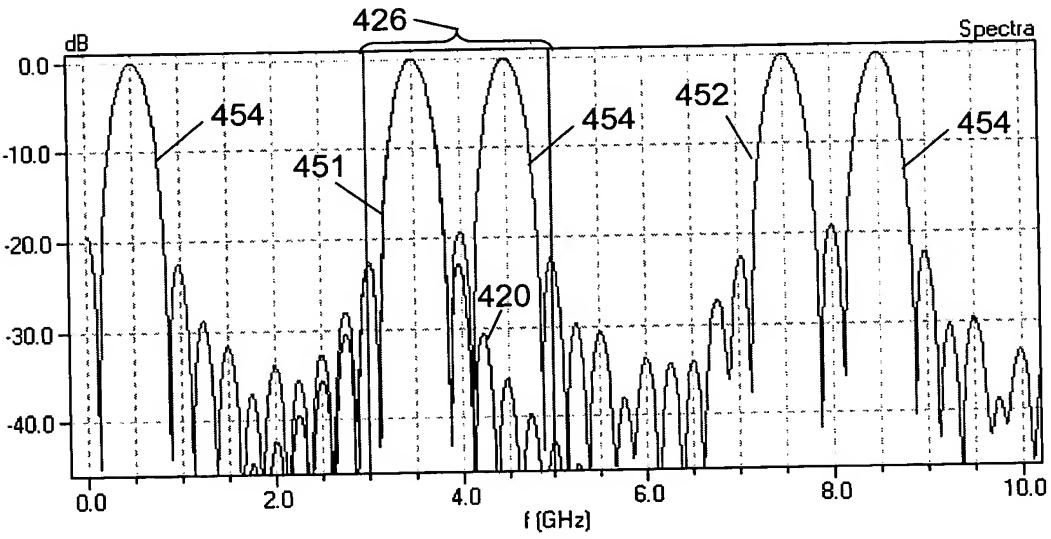

426
dB
Spectra
0.0
-10.0
-20.0
-30.0
-40.0
454
451
454
452
454
420
0.0
2.0
4.0
6.0
8.0
10.0
f (GHz)

FIG. 45

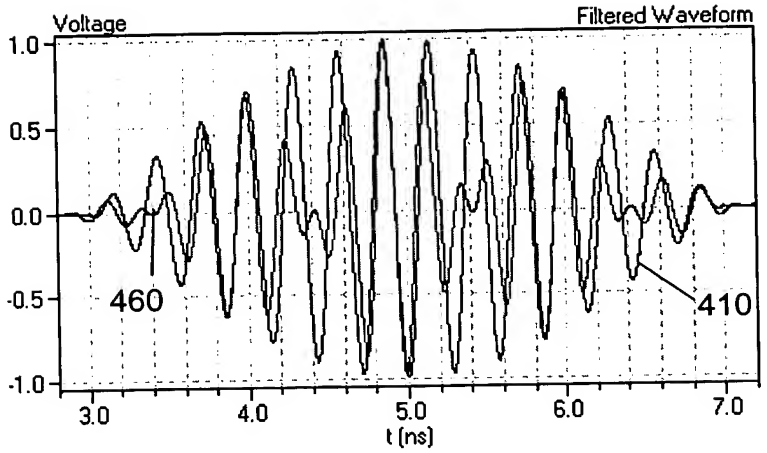

Voltage
Filtered Waveform
1.0
0.5
0.0
-0.5
-1.0
460
410
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 46

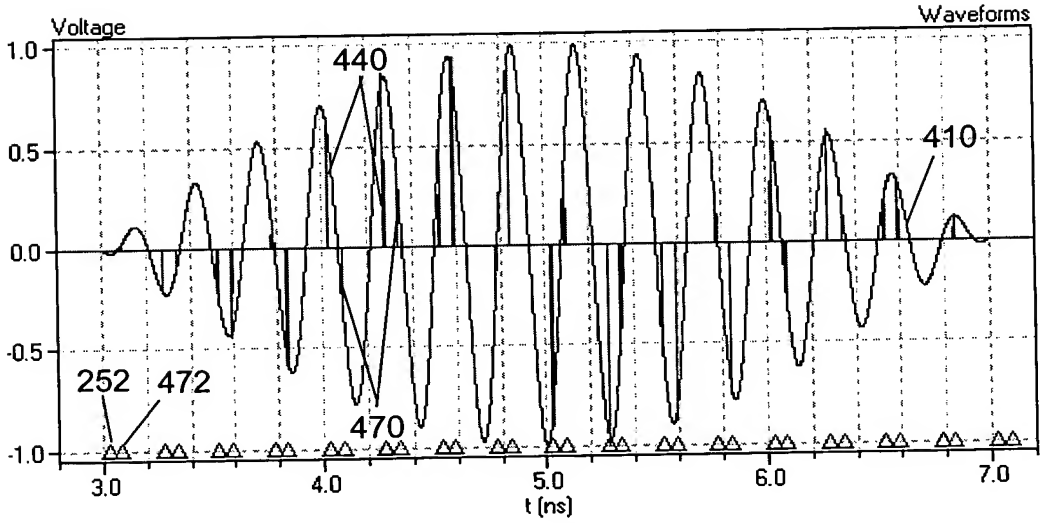

Voltage
Waveforms
1.0
0.5
0.0
-0.5
-1.0
440
410
252
472
470
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 47

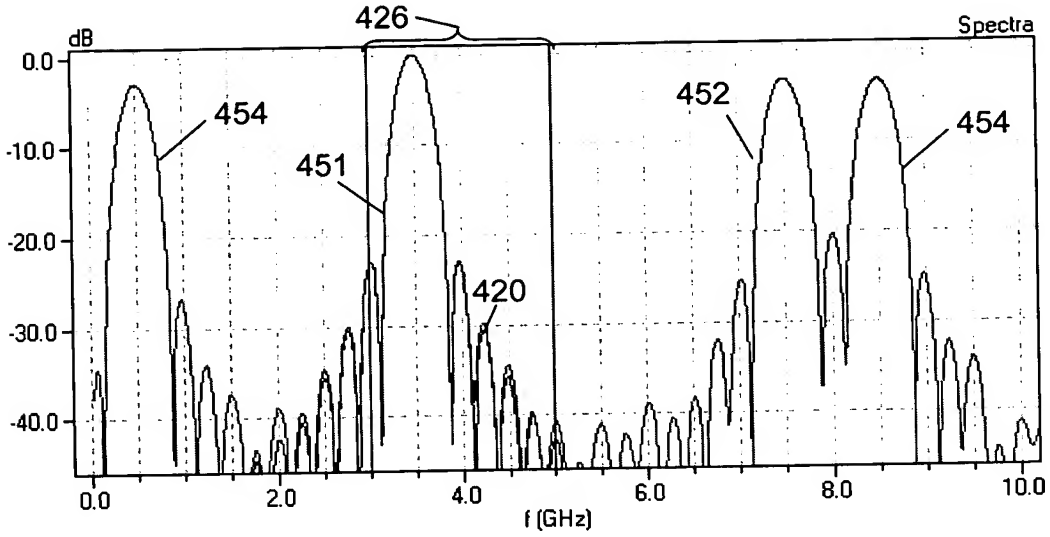

426
dB
Spectra
0.0
-10.0
-20.0
-30.0
-40.0
454
451
420
452
454
0.0
2.0
4.0
6.0
8.0
10.0
f (GHz)

FIG. 48

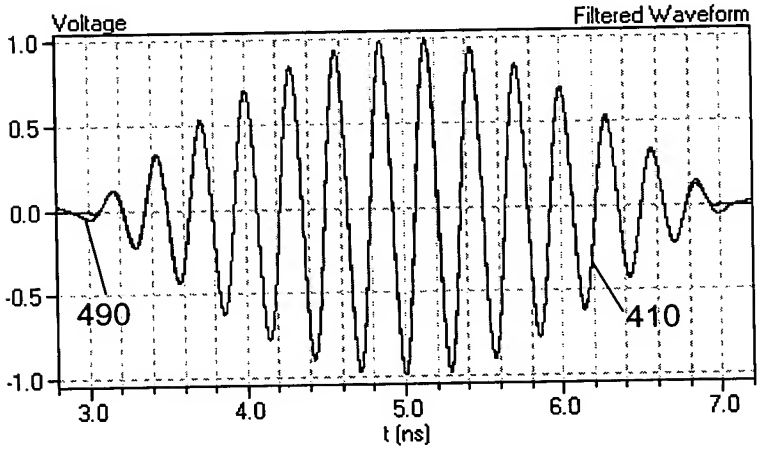

Voltage
Filtered Waveform
1.0
0.5
0.0
-0.5
-1.0
490
410
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 49

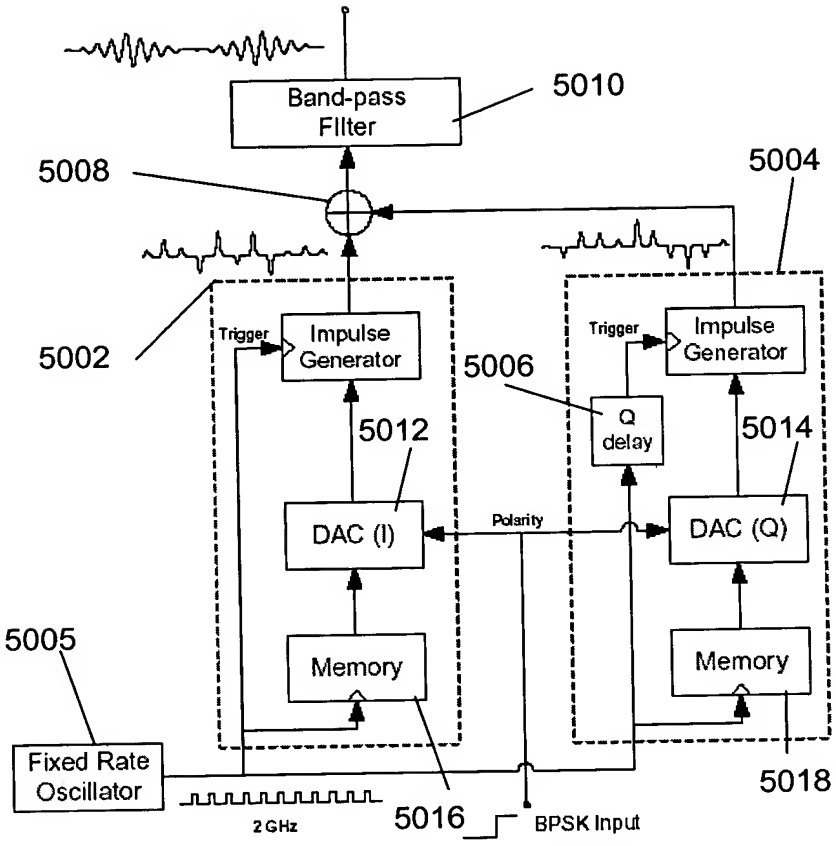

Band-pass
FIlter
5010
5008
5004
5002
Trigger
Impulse
Generator
5006
Q
delay
5012
5014
DAC (I)
Polarity
DAC (Q)
5005
Memory
Memory
Fixed Rate
Oscillator
2 GHz
5016
BPSK Input
5018

FIG. 50

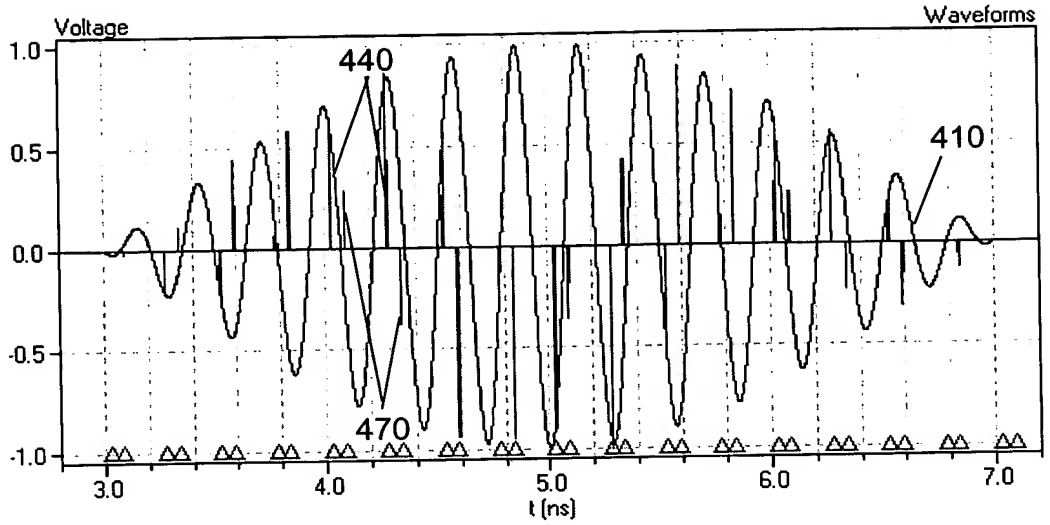

Voltage
Waveforms
1.0
0.5
0.0
-0.5
-1.0
440
410
470
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 51

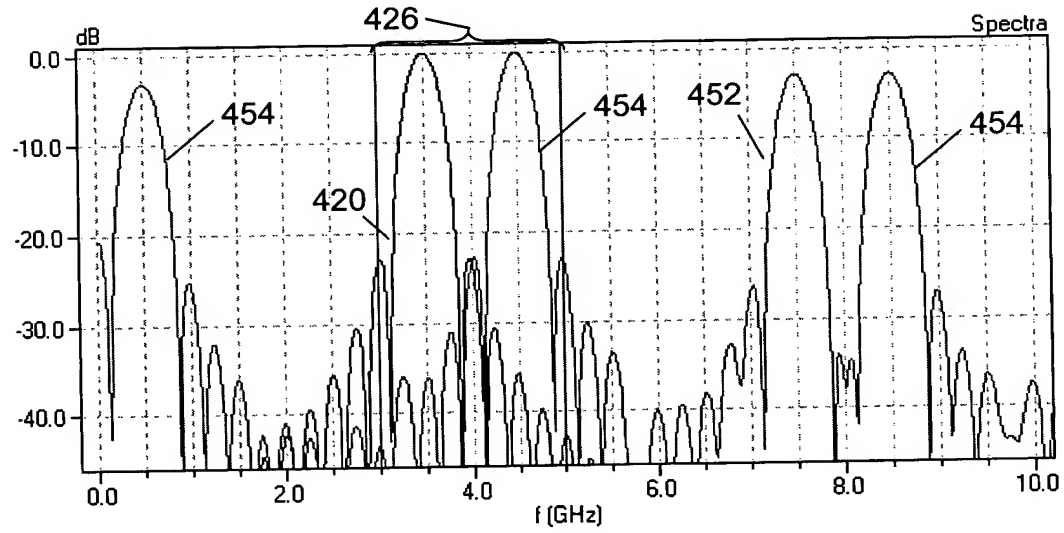

426
dB
Spectra
0.0
-10.0
-20.0
-30.0
-40.0
454
420
454
452
454
0.0
2.0
4.0
6.0
8.0
10.0
f (GHz)

FIG. 52

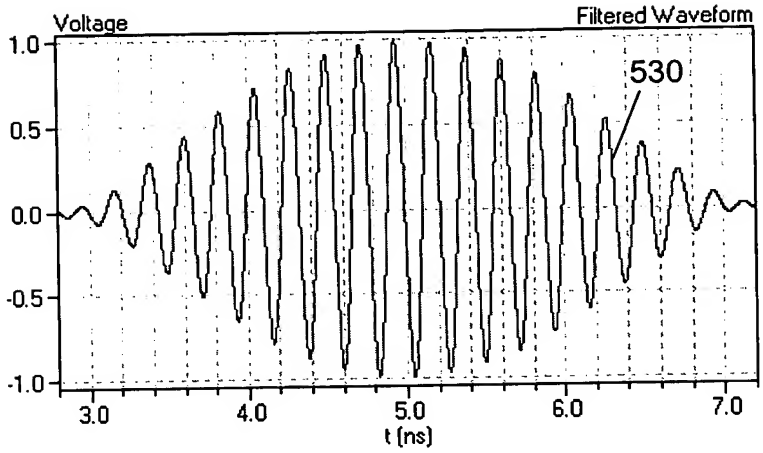

Voltage
Filtered Waveform
530
1.0
0.5
0.0
-0.5
-1.0
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 53

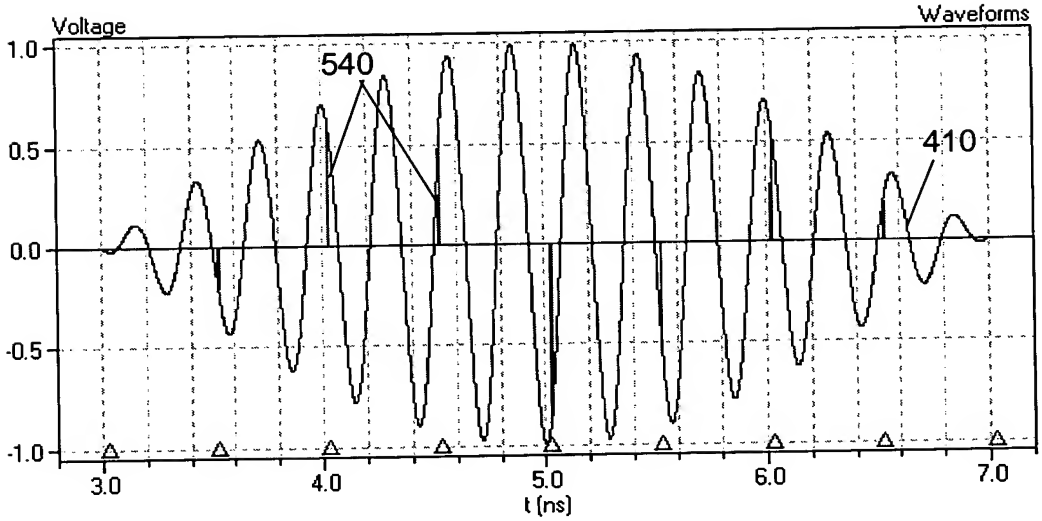

Voltage
Waveforms
540
410
1.0
0.5
0.0
-0.5
-1.0
3.0
4.0
5.0
6.0
7.0
t (ns)

FIG. 54

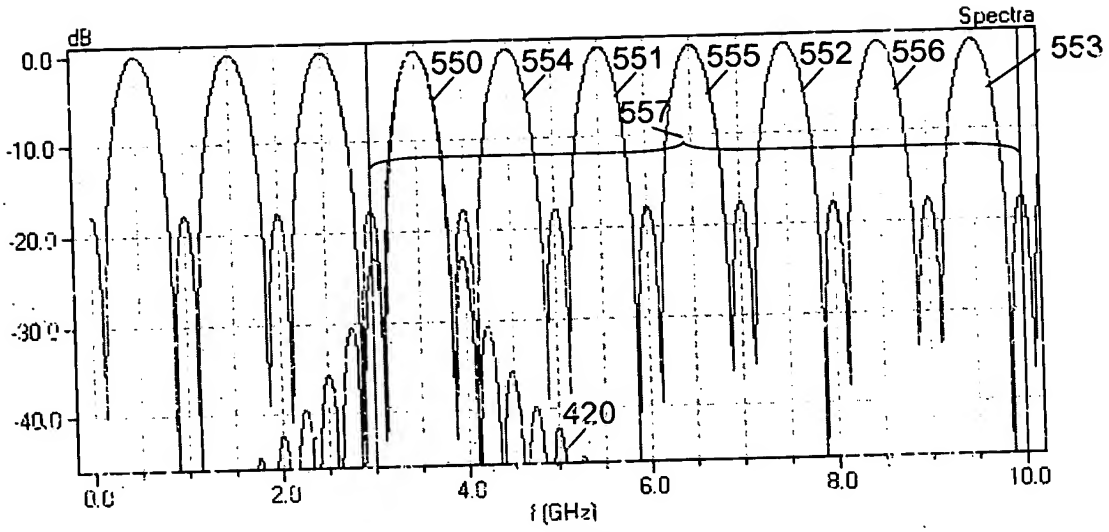

Spectra
dB
0.0
-10.0
-20.0
-30.0
-40.0
550
554
551
555
552
556
553
557
420
0.0
2.0
4.0
6.0
8.0
10.0
f (GHz)

FIG. 55

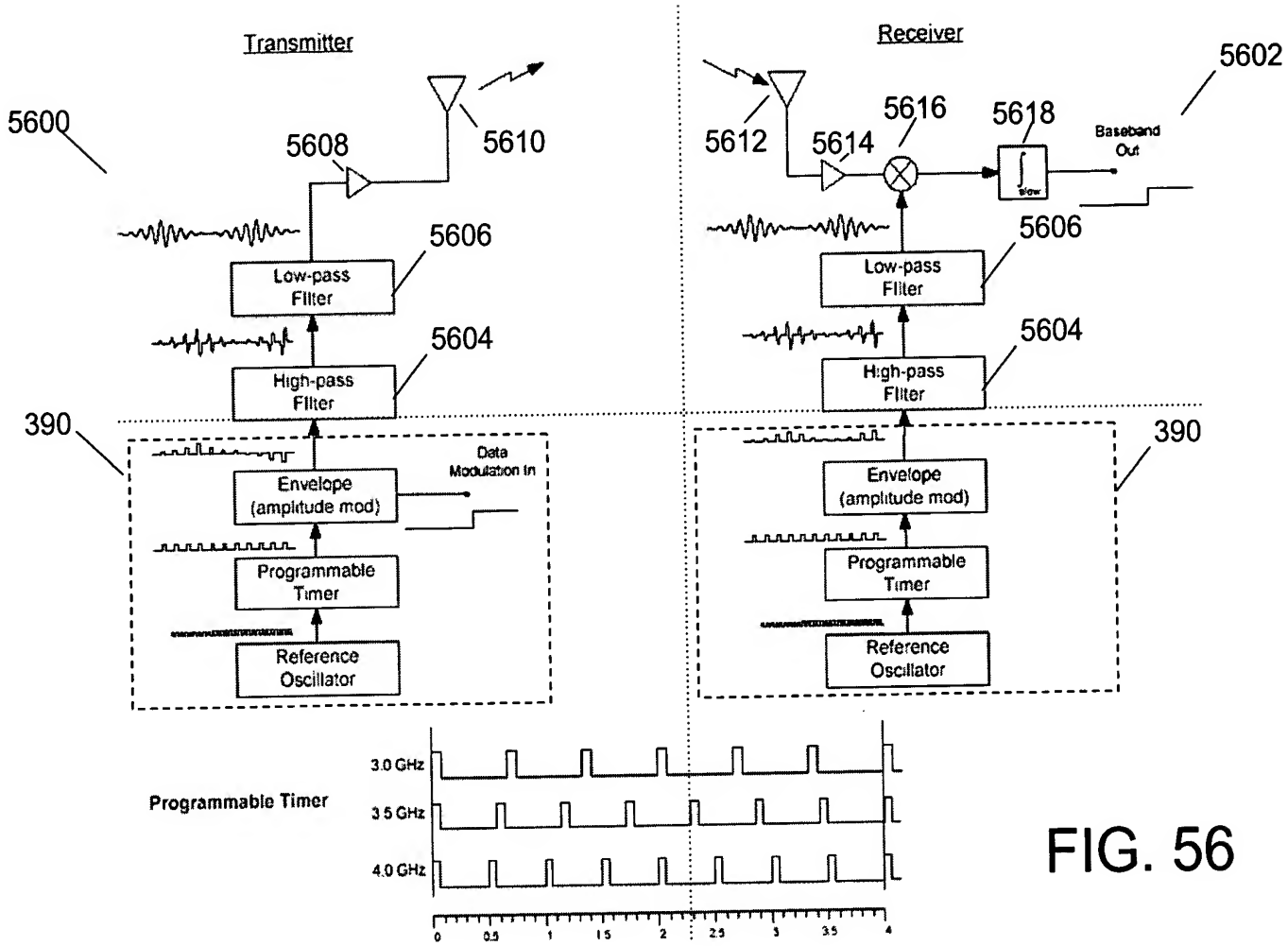

Transmitter
Receiver
5600
5602
5608
5610
5612
5614
5616
5618
Baseband Out
5606
5604
Low-pass Filter
High-pass Filter
390
Data Modulation In
Envelope (amplitude mod)
Programmable Timer
Reference Oscillator
Programmable Timer
3.0 GHz
3.5 GHz
4.0 GHz
0
0.5
1
1.5
2
2.5
3
3.5
4

FIG. 56

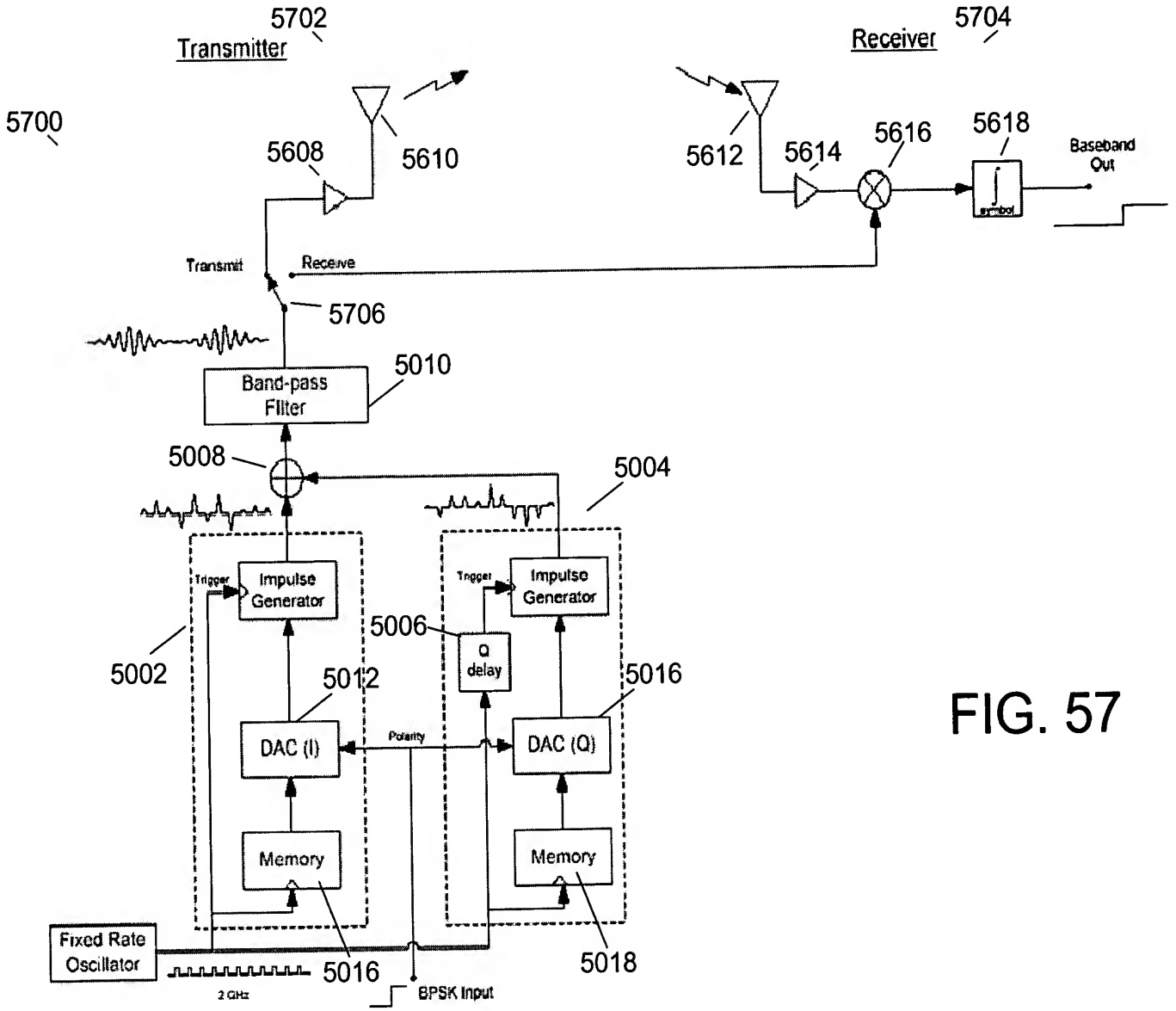

5700
5702
Transmitter
5704
Receiver
5608
5610
5612
5614
5616
5618
Baseband Out
Transmit
Receive
5706
5010
Band-pass Filter
5008
5004
Trigger
Impulse Generator
5002
5006
Q delay
5012
5016
DAC (I)
Polarity
DAC (Q)
Memory
Memory
Fixed Rate Oscillator
2 GHz
5016
5018
BPSK Input

FIG. 57

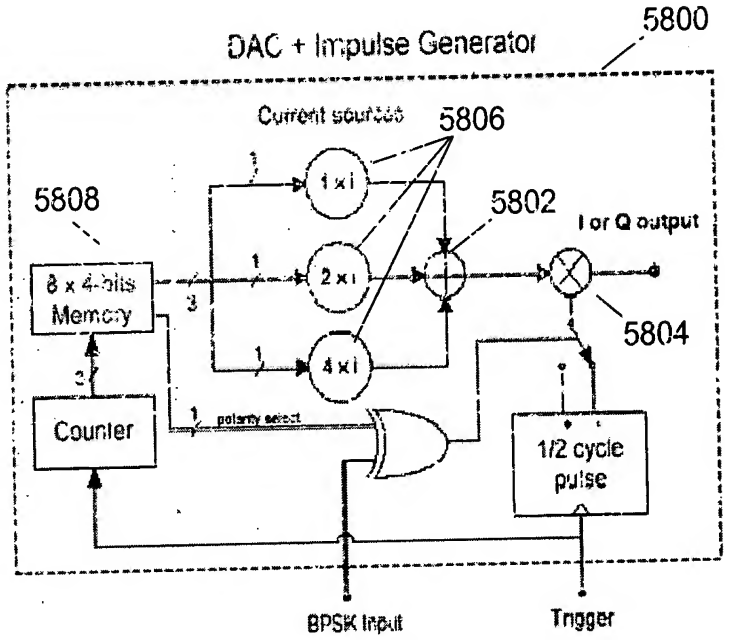

5800
DAC + Impulse Generator
Current sources
5806
5808
5802
I or Q output
8 x 4-bits Memory
1 x I
2 x I
4 x I
5804
Counter
polarity select
1/2 cycle pulse
BPSK Input
Trigger

FIG. 58

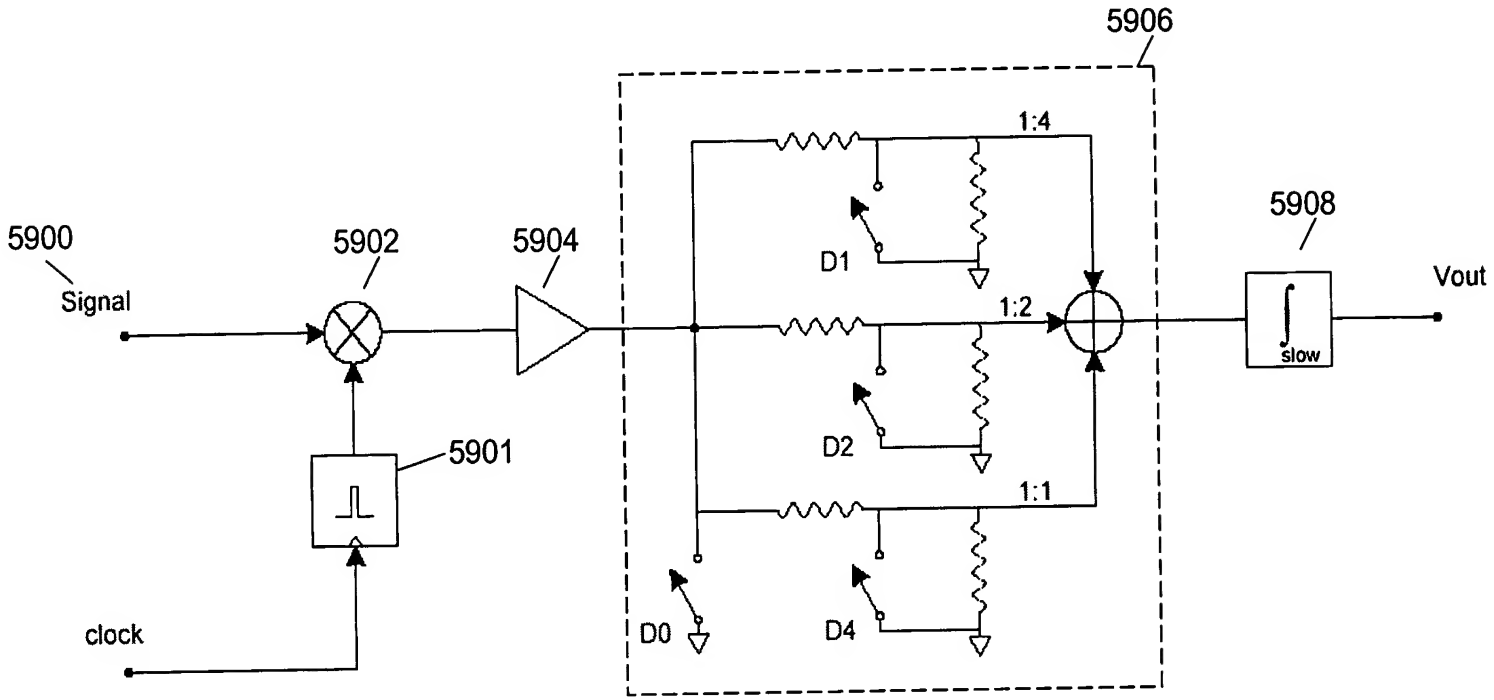

5906
1:4
5908
5900
5902
5904
D1
Vout
Signal
1:2
slow
D2
5901
1:1
clock
D0
D4

FIG. 59

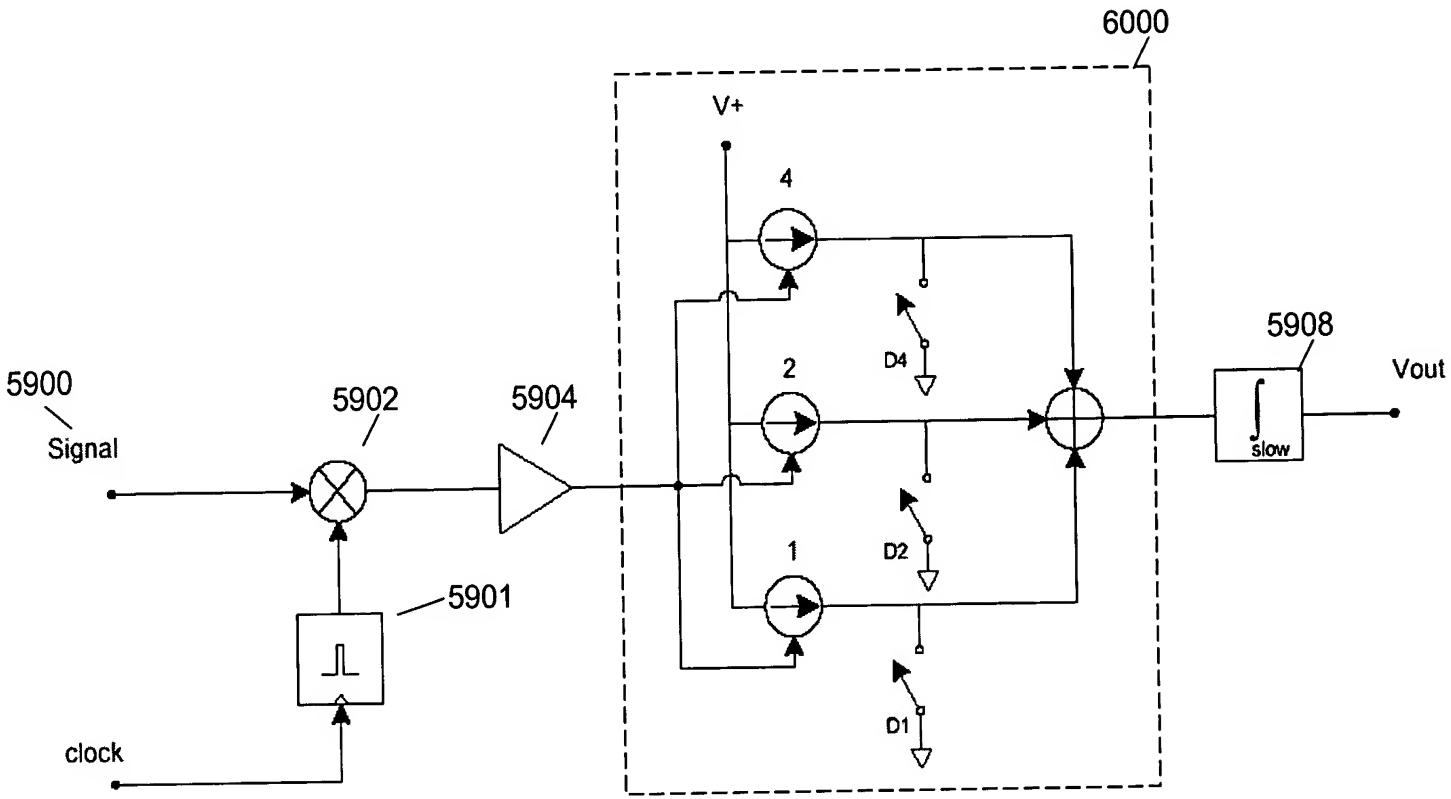

6000
V+
4
2
1
D4
D2
D1
5900
Signal
5902
5904
5901
clock
5908
slow
Vout

FIG. 60

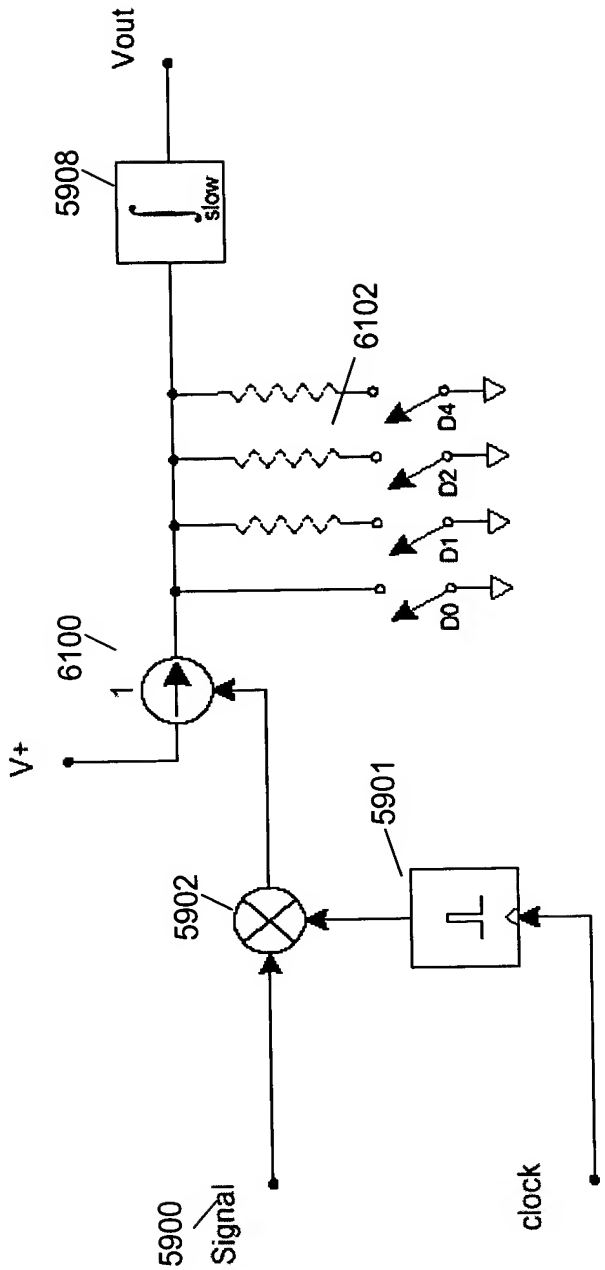

Vout
5908
$\int_{slow}$
6102
D4
D2
D1
D0
6100
1
V+
5901
5902
5900
Signal
clock

FIG. 61

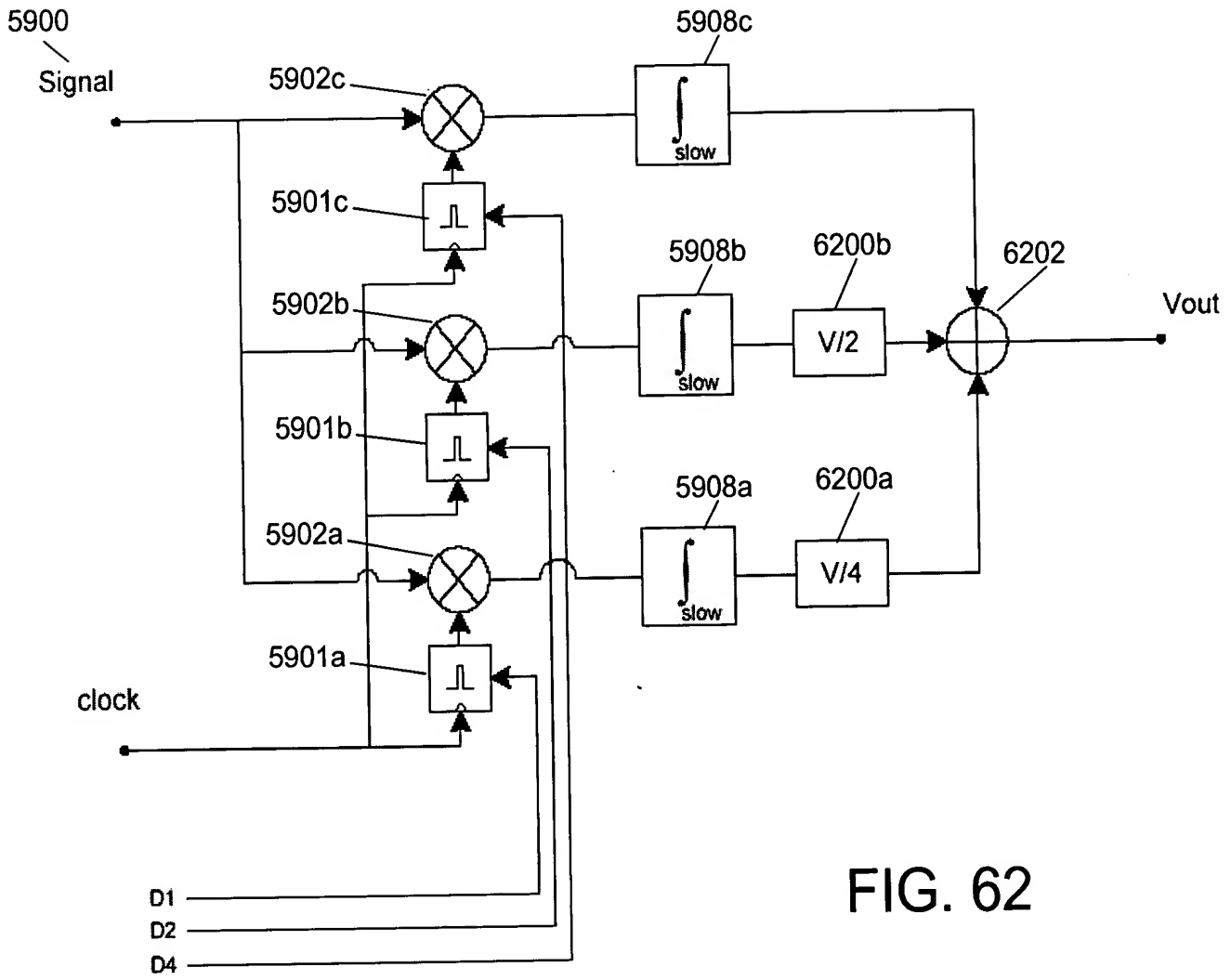

5900
Signal
5902c
5908c
slow
5901c
5908b
6200b
6202
5902b
Vout
V/2
slow
5901b
5908a
6200a
5902a
V/4
slow
5901a
clock
D1
D2
D4

FIG. 62

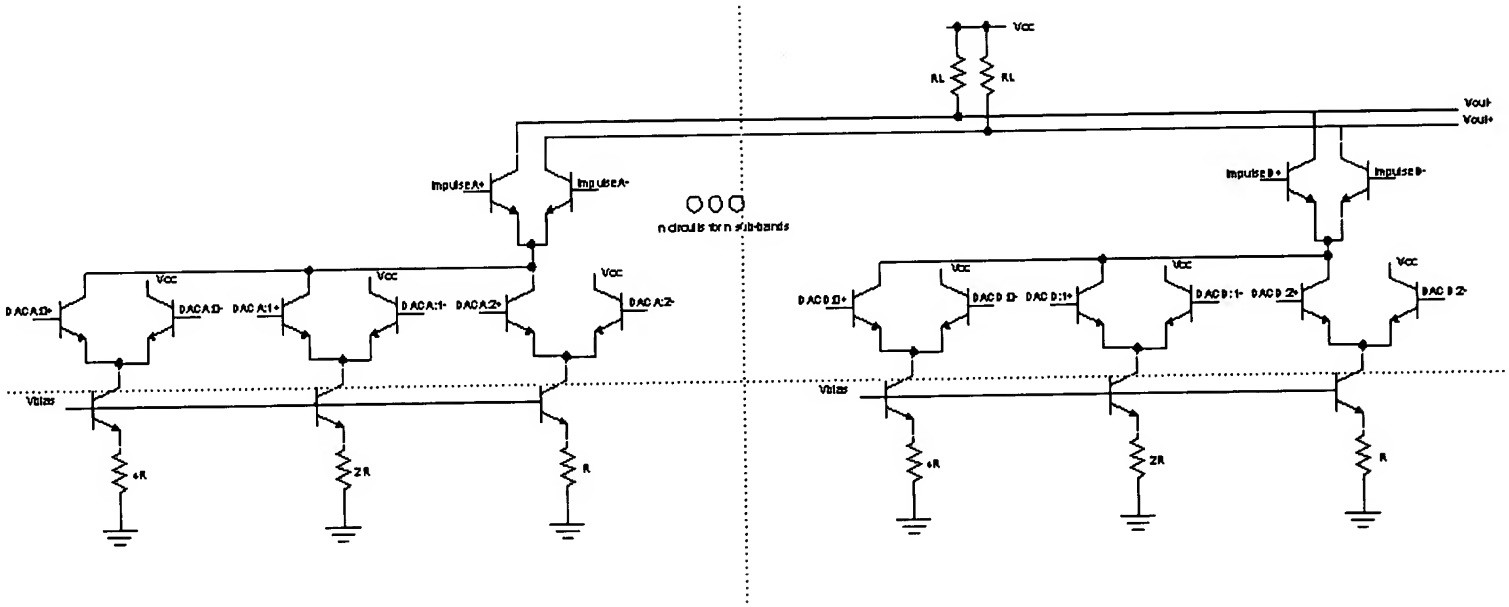

Vcc
RL
RL
Vout-
Vout+
ImpulseA+
ImpulseA-
n circuits for n sub-bands
ImpulseB+
ImpulseB-
Vcc
Vcc
Vcc
DACA:0+
DACA:0-
DACA:1+
DACA:1-
DACA:2+
DACA:2-
Vbias
+R
2R
R
Vcc
Vcc
Vcc
DACB:0+
DACB:0-
DACB:1+
DACB:1-
DACB:2+
DACB:2-
Vbias
+R
2R
R

FIG. 63

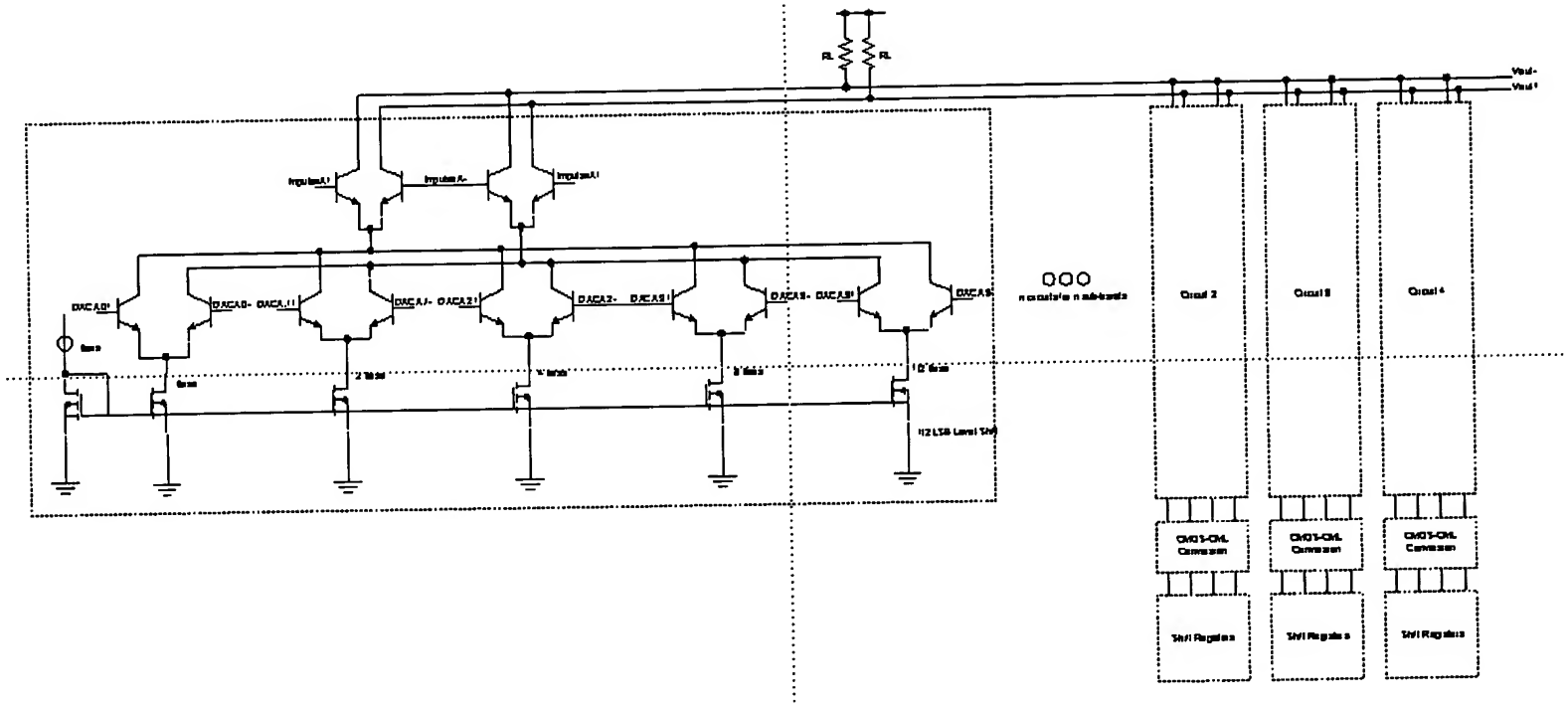
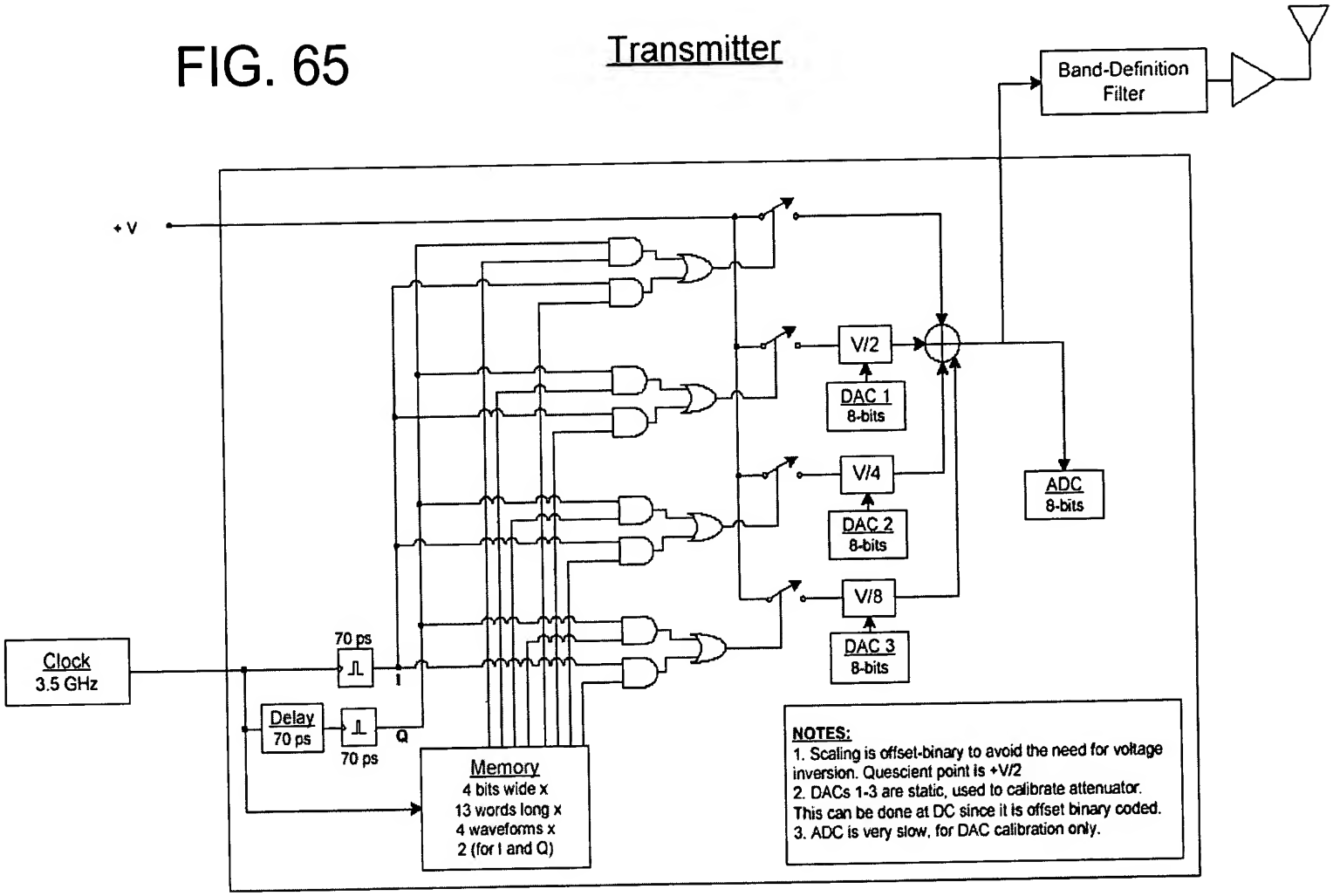


FIG. 64

FIG. 65


Transmitter
Band-Definition Filter
+V
V/2
DAC 1
8-bits
V/4
DAC 2
8-bits
V/8
DAC 3
8-bits
ADC
8-bits
Clock
3.5 GHz
70 ps
I
Delay
70 ps
Q
70 ps
Memory
4 bits wide x
13 words long x
4 waveforms x
2 (for I and Q)
NOTES:
1. Scaling is offset-binary to avoid the need for voltage inversion. Quescient point is +V/2
2. DACs 1-3 are static, used to calibrate attenuator. This can be done at DC since it is offset binary coded.
3. ADC is very slow, for DAC calibration only.

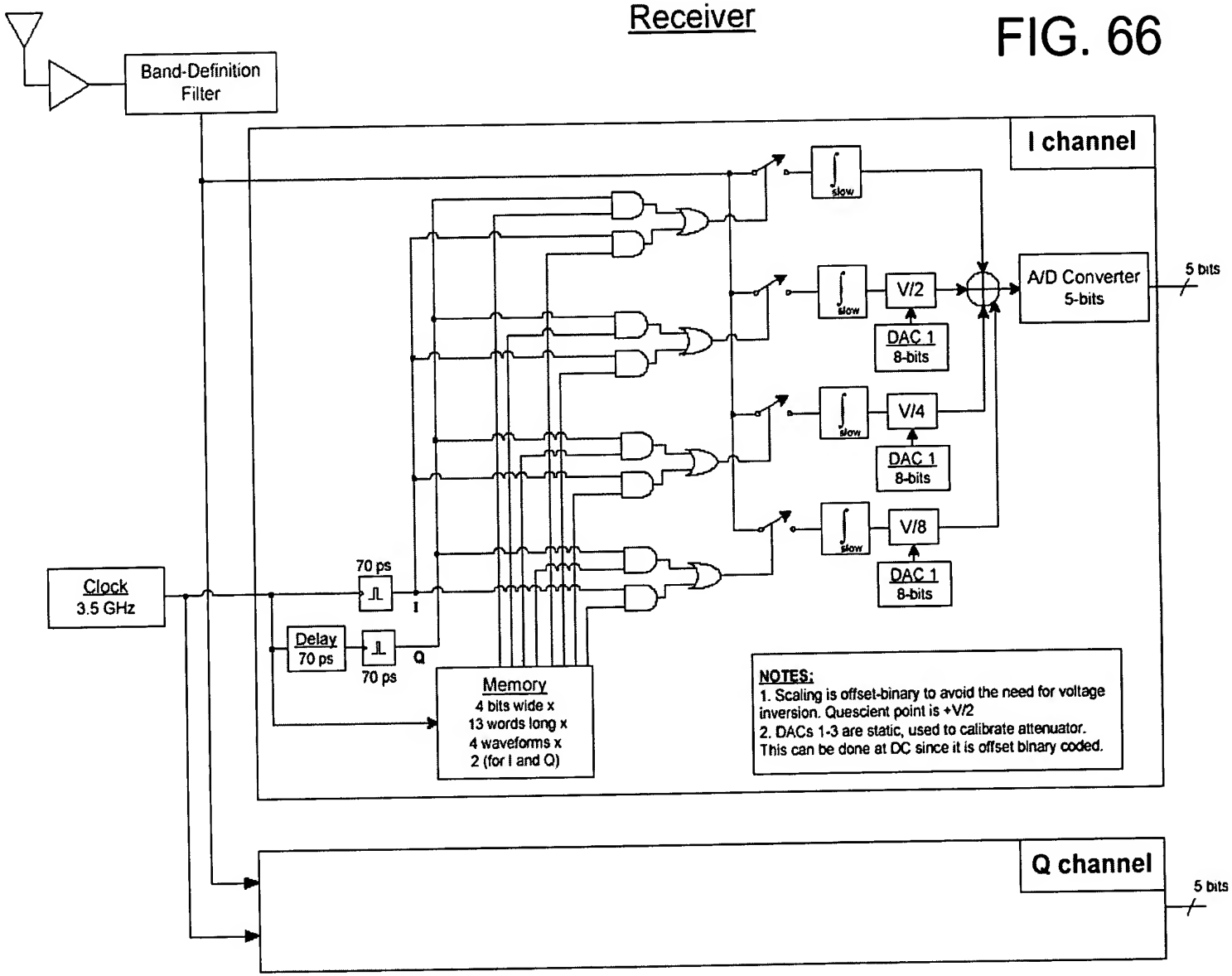

Receiver
Band-Definition Filter
I channel
slow
V/2
DAC 1 8-bits
V/4
DAC 1 8-bits
V/8
DAC 1 8-bits
A/D Converter 5-bits
5 bits
Clock 3.5 GHz
70 ps
I
Delay 70 ps
70 ps
Q
Memory
4 bits wide x
13 words long x
4 waveforms x
2 (for I and Q)
NOTES:
1. Scaling is offset-binary to avoid the need for voltage inversion. Quescient point is +V/2
2. DACs 1-3 are static, used to calibrate attenuator. This can be done at DC since it is offset binary coded.
Q channel
5 bits

FIG. 66

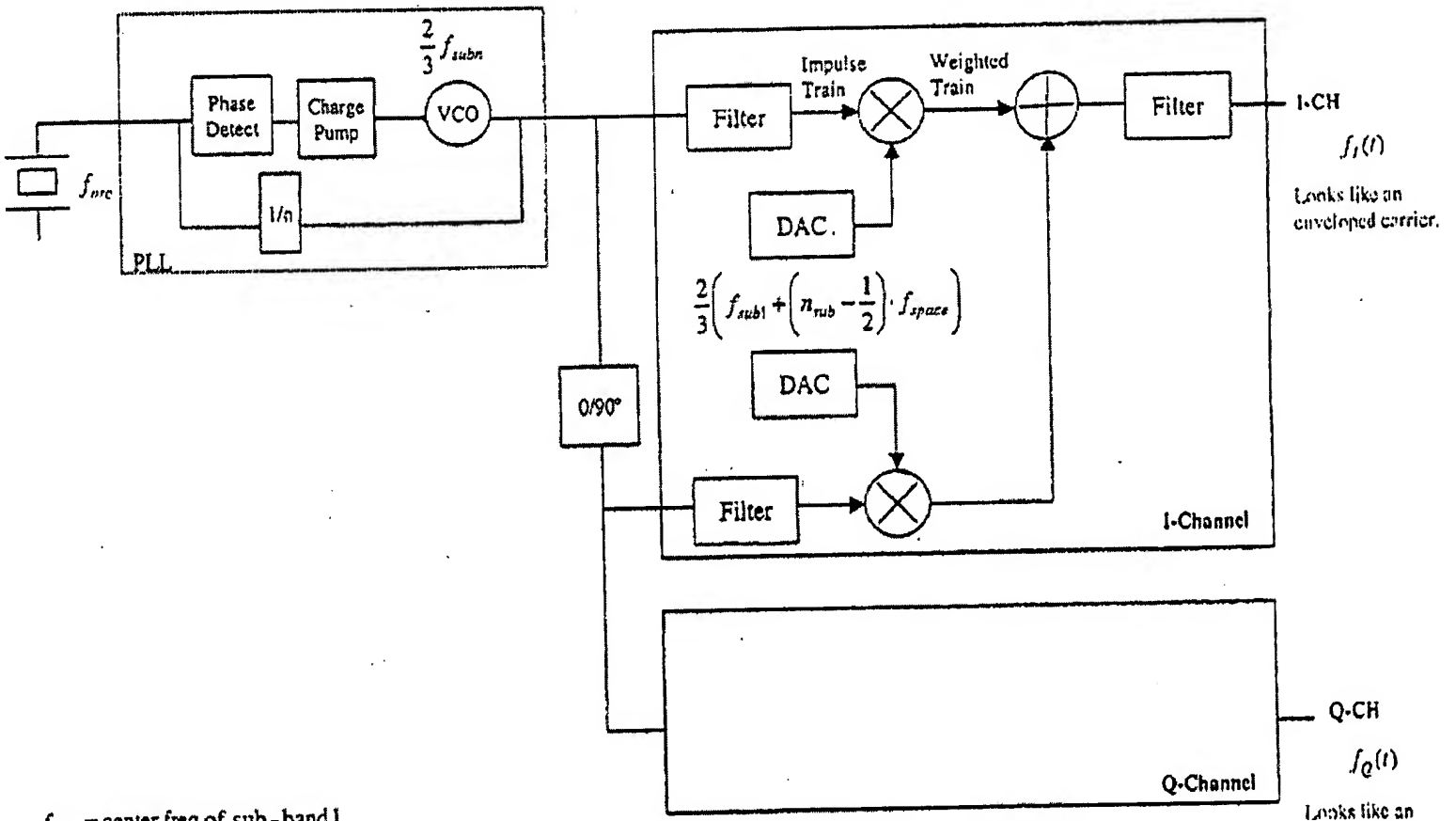

$\frac{2}{3} f_{subn}$
Phase Detect
Charge Pump
VCO
f_{src}
1/n
PLL
Impulse Train
Weighted Train
Filter
Filter
I-CH
$f_I(t)$
Looks like an enveloped carrier.
DAC.
$\frac{2}{3}\left(f_{sub1} + \left(n_{sub} - \frac{1}{2}\right) \cdot f_{space}\right)$
DAC
0/90°
Filter
I-Channel
Q-Channel
Q-CH
$f_Q(t)$
Looks like an enveloped carrier.
f_{sub1} = center freq of sub-band 1
f_{space} = sub-band spacing
f_{subn} = center frequency of sub-band n

FIG. 67

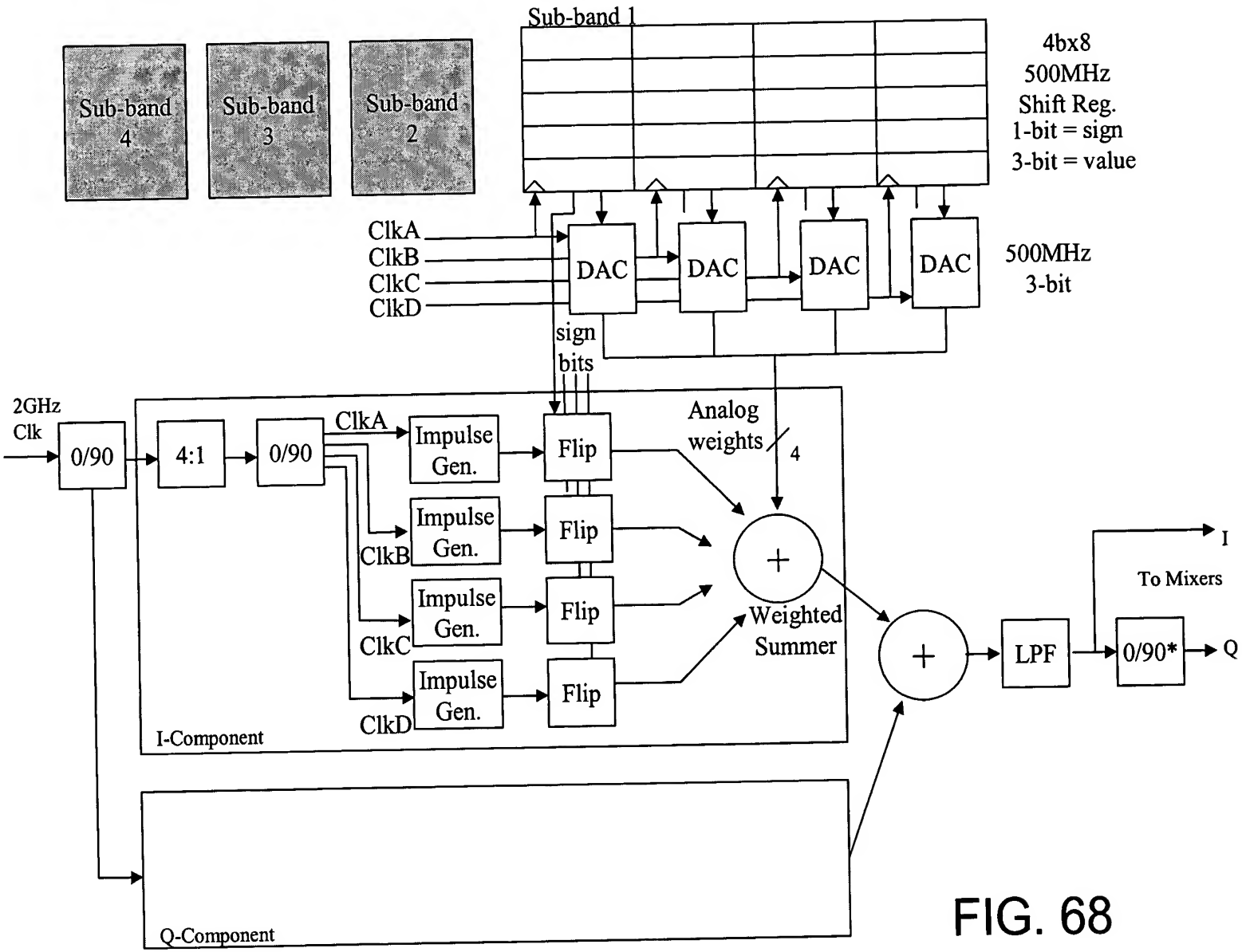

Sub-band 1
Sub-band 4
Sub-band 3
Sub-band 2
4bx8
500MHz
Shift Reg.
1-bit = sign
3-bit = value
ClkA
ClkB
ClkC
ClkD
DAC
DAC
DAC
DAC
500MHz
3-bit
sign bits
2GHz Clk
0/90
4:1
0/90
ClkA
Impulse Gen.
Flip
Analog weights
4
ClkB
Impulse Gen.
Flip
ClkC
Impulse Gen.
Flip
ClkD
Impulse Gen.
Flip
Weighted Summer
I-Component
Q-Component
LPF
I
To Mixers
0/90*
Q

FIG. 68

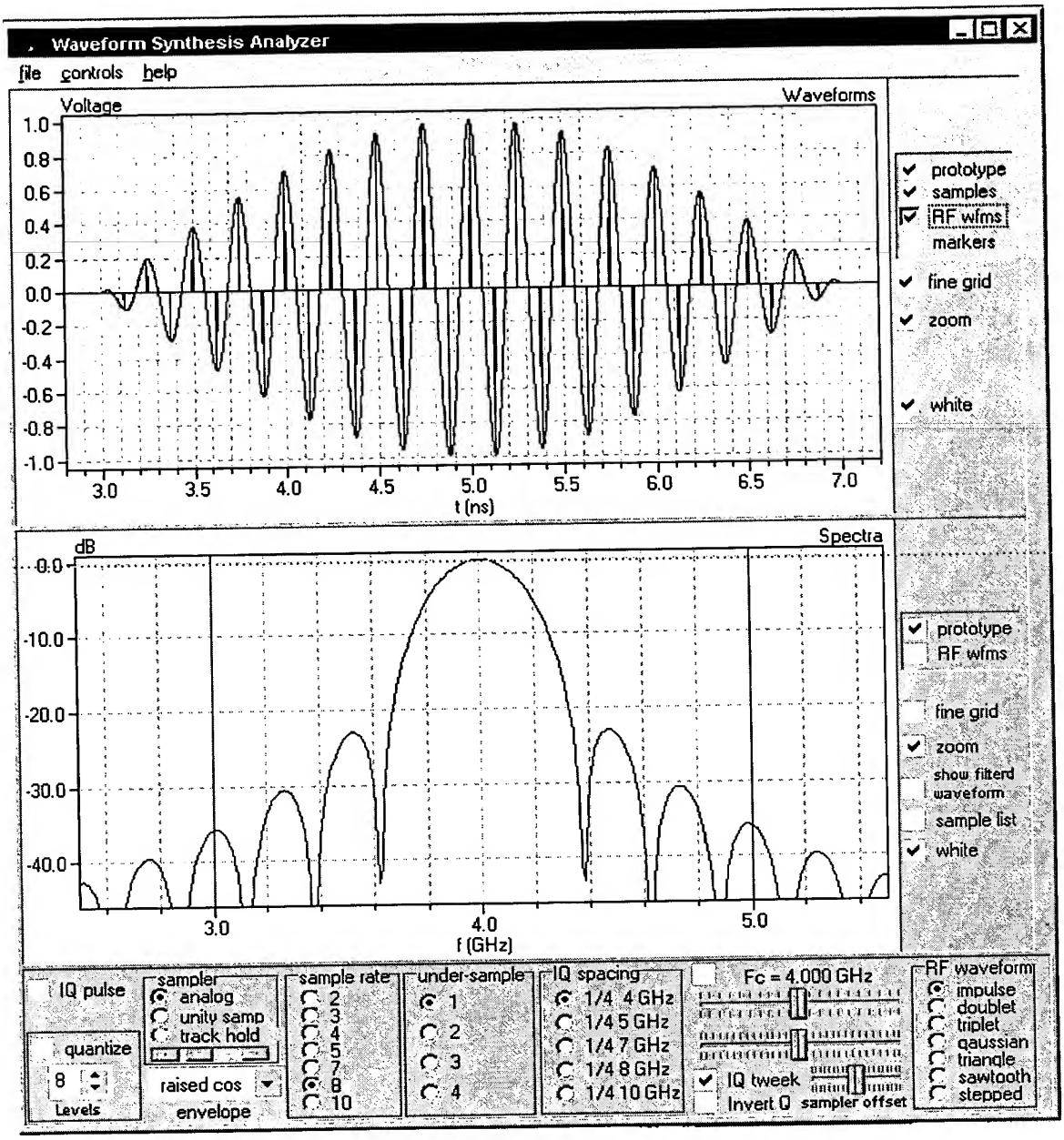

Waveform Synthesis Analyzer
file controls help
Voltage
Waveforms
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
3.0 3.5 4.0 4.5 5.0 5.5 6.0 6.5 7.0
t (ns)
prototype
samples
RF wfms
markers
fine grid
zoom
white
dB
Spectra
-0.0
-10.0
-20.0
-30.0
-40.0
3.0 4.0 5.0
f (GHz)
prototype
RF wfms
fine grid
zoom
show filterd waveform
sample list
white
IQ pulse
quantize
8
Levels
sampler
analog
unity samp
track hold
raised cos
envelope
sample rate
2 3 4 5 7 8 10
under-sample
1 2 3 4
IQ spacing
1/4 4 GHz
1/4 5 GHz
1/4 7 GHz
1/4 8 GHz
1/4 10 GHz
Fc = 4.000 GHz
IQ tweek
Invert Q
sampler offset
RF waveform
impulse
doublet
triplet
gaussian
triangle
sawtooth
stepped

FIG. 69

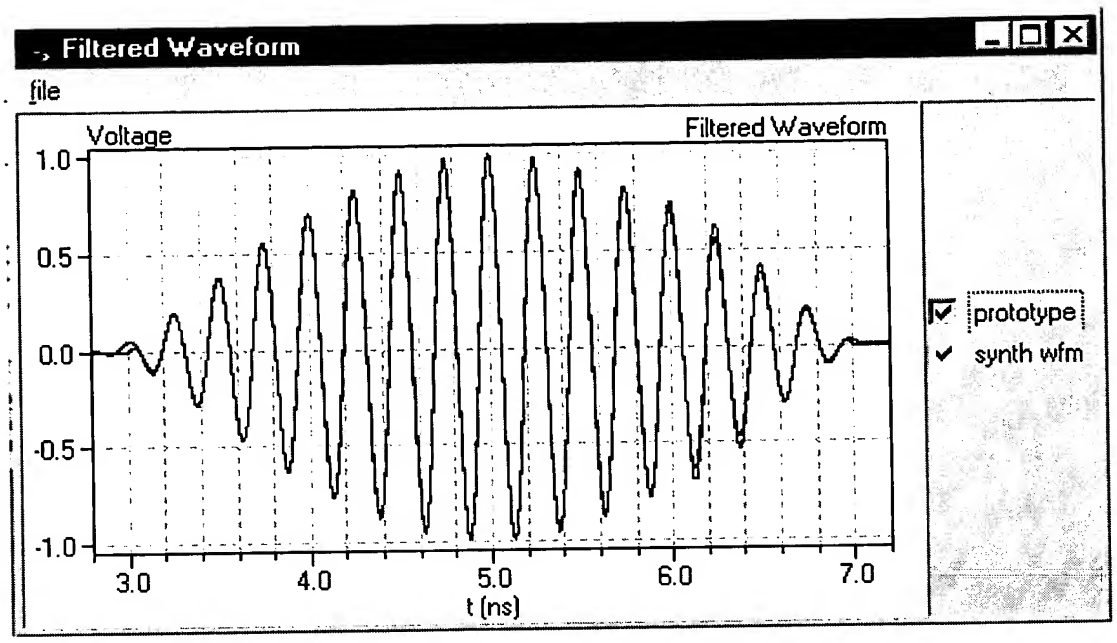

Filtered Waveform
file
Voltage
Filtered Waveform
1.0
0.5
0.0
-0.5
-1.0
3.0
4.0
5.0
6.0
7.0
t (ns)
prototype
synth wfm

FIG. 70

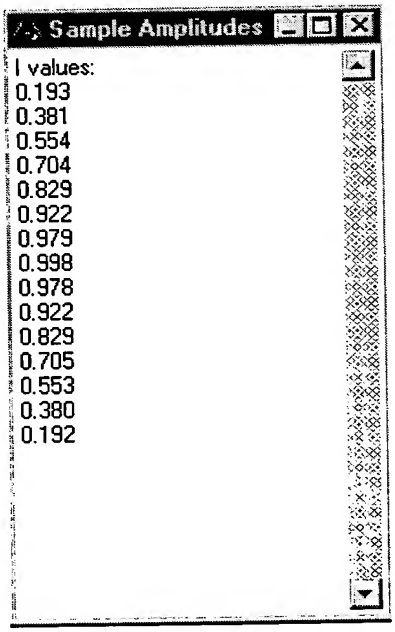

Sample Amplitudes
I values:
0.193
0.381
0.554
0.704
0.829
0.922
0.979
0.998
0.978
0.922
0.829
0.705
0.553
0.380
0.192

FIG. 71